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2001: A Time Capsule 73

Still a benchmark by which space films, old and new, are judged, *2001: A Space Odyssey* has enthralled science fiction devotees for more than three decades with its purposefully ambiguous take on man's imagined first contact with an extraterrestrial intelligence. In this, its namesake year, *Cinefex* pays tribute to this seminal film with a comprehensive retrospective, culled from in-depth interviews with many of its principal technicians and craftsmen—some no longer with us—who were instrumental in bringing legendary director Stanley Kubrick's timeless, profound and startlingly realistic-looking vision of deep space exploration to the screen. From its inception as a novel and screenplay—a corroborative effort by Kubrick and science fiction maestro Arthur C. Clarke—through its painstaking, often frustrating, four-year-long odyssey, the epic undertaking continually tested the skills and resourcefulness of such innovators as special effects supervisors Douglas Trumbull and Wally Gentleman, production designer Tony Masters, cinematographer John Alcott, makeup artist Stuart Frechorn and others whose recollections form the foundation of this account. Challenged by Kubrick's ever the perfectionist, all rose to the occasion, exploring countless concepts and approaches, and, in an era long before computers and motion control were endemic to visual effects, devising imaginative and heretofore untried techniques and equipment that would pave the way for future generations of filmmakers. *Article by Don Shay and Jody Duncan.*

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COVER—The *Discovery* mission begins to unravel in *2001: A Space Odyssey*.

WARRIOR KINGS

ARTICLE BY Joe Fordham

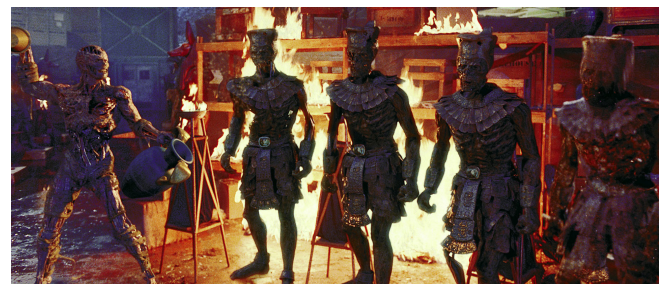


Two weeks before the debut of *The Phantom Menace*, when excitement over the long-awaited *Star Wars* prequel was at its absolute peak, Universal Pictures boldly stormed into multiplexes with a stylishly spruced-up remake of its sixty-seven-year-old horror classic, *The Mummy*. Written and directed by Stephen Sommers, the film reimagined the tale of Imhotep, the ancient Egyptian brought back from the dead, as a wide-screen action adventure set in Egypt in 1925. Brendan Fraser led the cast as Rick O'Connell, an errant Foreign Legionnaire, caught up in the pursuit of ancient artifacts with a feisty young librarian, Evelyn Carnahan, and her bumbling archeologist brother, Jonathan.

Key to the realization of Sommers' vision were visual effects supervisor John Berton and his digital team at Industrial Light & Magic, who were on hand to resurrect Imhotep as a shambling, desiccated corpse, created through a combination of motion capture and key-frame animation. Also conjured up for the sweeping story were swarms of priest and soldier mummies, biblical cataclysms, flashbacks to 2000 B.C., mystical sand-shifting apparitions, and droves of flesh-eating scarab beetles. Primed for summer spectacle, audiences flocked to the picture, which grossed in excess of \$43 million in its opening weekend and more than \$155 million domestically over the next four months.



Desiccated and crumbling, Imhotep rises once again- courtesy of Industrial Light & Magic - in the Stephen Sommers horror sequel *The Mummy Returns*.



Attempting to thwart his old enemy, Rick O'Connell, Imhotep reanimates four soldier mummies within the British Museum. All of *The Mummy* characters are digital creations.

With that boxoffice performance and an established horror franchise, it was all but inevitable that Imhotep would rise again. "I heard about a sequel two days after *The Mummy* hit theaters," remarked John Berton. "Stephen and I had been talking about it even earlier than that, kicking around ideas as we were wrapping up the first production. We thought about how we would finish the first picture with an eye towards a second one. Stephen was already cooking on ideas by the time *The Mummy* opened, and we started talking about effects. By the end of 1999, we were in possession of the script and our design work began."

Along with Berton, production designer Allan Cameron, film editor Bob Ducsay and director of photography Adrian Biddle also returned to work with Sommers on the sequel. Key members of the ILM *Mummy* crew resuming their roles in resurrecting Imhotep included animation director Daniel Jeannette and visual effects art director Alex Laurant. Makeup effects designer Nick Dudman was also called back to provide physical mummy incarnations, while mechanical effects designer Neil Corbould took over duties from his elder brother Chris, who was working on *Tomb Raider*.

The brief to all departments was simple. "We knew that we needed to give audiences a reason to come back and leave just as satisfied as they had the first time," said Berton. "When Stephen first approached us with *The Mummy*, he had already written the script and was looking for ways to work in the effects. This time, he was looking for ideas even before he had a script. My advice to him was to use his imagination to go further than we had in the first movie, to top ourselves in every possible way. Stephen understood that intuitively, of course; but in terms of the visual effects, it had to be bigger, better, bolder- and all the creatures surrounding Imhotep had to be more amazing."

Set ten years after the events of the first film, *The Mummy Returns* picks up with Rick and Evelyn (Rachel Weisz) as a married couple on an expedition with their young son Alex (Freddie Boath). Together, they stumble across the mysterious gold bracelet of Anubis- once property of a fearsome warrior, the Scorpion King. The O'Connells bring the bracelet back to London, but before they can add it to the great repository of Egyptian antiquities at the British Museum, Evy is abducted. O'Connell traces her to the museum, where he discovers that members of an ancient cult have revived his old nemesis Imhotep (Arnold Vosloo). Evy's rescue turns into a chase as Imhotep's minions pursue the O'Connells through the streets of London, intent upon securing the bracelet of Anubis. Alex is kidnapped, whisked away to Egypt, and a race begins to rescue the boy before Imhotep can use him to unleash the Scorpion King's powers.

Throughout preproduction, Alex Laurant- under ILM art department supervisor Mark Moore- developed visual concepts for environments, taking cues from the script and from designs emerging from the art department. Location scouting was conducted in Morocco- where the first film was shot- as well as Jordan and Egypt itself. When logistics precluded an Egyptian shoot, it was decided that ILM would re-create its ancient monuments in a more accessible setting. But one major location still remained- the oasis of Ahm Shere, a tangle of jungle in the middle of a vast desert, adjacent to a river canyon but secluded enough to hide the golden pyramid of them Scorpion King.

Laurant first produced a pencil rendering of the oasis, depicting O'Connell and company sailing a dirigible toward the pyramid, located in a primeval crater with sheer rock walls. The fanciful concept, when scanned and printed with a sepia tint in Photoshop, was reminiscent of the artwork of Ray Harryhausen. "Stephen told us later that sketch was the first real design that captured the period romance and the epic sweep of that part in the movie," said Laurant. "He also mentioned that when he showed that illustration to Brendan Fraser, it got Brendan even more excited about doing the sequel."

Subsequent designs refined the oasis concept, expanding the scale while addressing story issues and location details. "The design process allowed me to make my case for geographically-specific issues, like the steepness of the cliffs," explained Laurant. "At one point, we were discussing making the cliff walls very smooth, as if a bowl had been pressed into the sand. I used these drawings to lobby for a little more drama; so when the characters first come out of this canyon into the oasis, they are flanked by vertical sheer cliff walls." Laurant's final color rendering, looking out into the oasis across distant waterfalls and King Kong-inspired forests, would become the basis for a digital matte painting that established the setting.

Character design consumed much of ILM's preproduction time, as it had on the first film. Although Laurant, Berton and Jeannette, in theory, already had their leading man in the ILM data banks, technological advances and the need for lingering shots of the desiccated star dictated a new approach to Imhotep. "On the first film," observed Berton, "we went through a tremendous amount of research and development to create Imhotep, so we did leapfrog off that- but a lot has been going on at ILM with creatures in the last two years. One of our most important advances has been improving our understanding of how to utilize motion capture to get a really great performance onto a computer graphics character. On the first film, Imhotep was someone we didn't know. We had to introduce him and have him rise from the grave. He was much more of a scary monster threat, just by the very fact that he existed. In this film, we know that he exists. This time, he has to interact more integrally with the other characters."

Daniel Jeannette worked with motion capture supervisor Seth Rosenthal in the development of a revised technical approach to the motion capture used on *The Mummy*, incorporating an Oxford Metric Vicon motion capture system with commercially available real-time rendering software designed for producing computer games. This allowed a motion capture performer to view, in real time, his own performance composited into background plates as a three-dimensional computer graphics character. "We wanted to retain more of Arnold Vosloo's performance than we were able to do on *The Mummy*," said Jeannette. "By allowing Arnold to perform his CG character to the pre-edited sequence, we enabled him to interact physically with characters that were in front of him in the scene and we could guarantee that his performance would be integral to the plate. We could see his performance play in the context of the shot." The new approach allowed Vosloo to perform continuous takes where the action cut from closeup to wide shot, with key-frame animation employed to tweak any mismatches.

Imhotep's physical appearance was essentially the same as stage two of the five-phase progression from corpse to man developed for the first movie.

"Stephen didn't want to go back to stage one," said Jeannette, "which was much more of a skeletal figure, with globular eyes, that bore no real likeness to Arnold Vosloo. Stage two was a little closer to Arnold, although we only saw this for approximately five shots in *The Mummy*. We actually did a little bit of a face-lift to bring that stage closer to Arnold's physical appearance." To

further impart Vosloo's performance to the CG character, Jeannette set up high-definition video cameras to shoot straight-on and profile closeups of the actor's face as he delivered his lines. "This gave us the facial expressions we needed to reanimate the shots. It became the ground material that the animators used to bring Imhotep's performance to a level of realism that matched Arnold's."

Among the new characters on display in *The Mummy Returns* were nine-foot-tall, dog-headed warriors, first seen in a prologue set in Thebes in 3112 B.C., then appearing later at the film's climax. Berton invited character design ideas from across the ILM art department, from which Sommers chose a rendering by Carlos Huanté of a roaring, bipedal canine clad in Egyptian war regalia. "When they were first mentioned in the script," stated Laurant, "the Anubis warriors were described as skeletal and mummy-like. In Carlos' painting, the Anubis warrior was not mummified, but was instead a healthy, full-musculatured creature. Since this design captured the spirit of the character for Stephen, it became our stylistic bible."

Laurant and Jeannette worked from the Huanté illustration to develop anatomical studies of the human/canine hybrids, allowing for their degraded reappearance later in the picture. The final pencil-drawn pose was rendered in three overlays depicting the Anubis warrior's skeletal structure, a subcutaneous muscle layer, and a version of warrior clad only in bikini briefs.

"Essentially we gave him a human musculature, proportionally blended, to convey the mechanics convincingly," Laurant explained. "Then we digitally enhanced the final drawings to include designs for the armor." While Viewpaint artists Catherine Craig, Derek Gillingham and Rebecca Heske concentrated on renderings of various orientations of Anubis armor textures, Richard Miller sculpted fourteen-inch-tall clay maquettes of the creatures as a tactile real-world reference for CG modeling supervisor George Aleco-Sima and his team.

For Sommers, the key to the appearance of the Anubis warrior was its backward-bent canine leg. Though basic animation would often be provided by motion capturing a performer, no human could possibly replicate the creature's gait- nor match its running speed, estimated to exceed fifty miles per hour. Lead technical animator Chris Mitchell developed a procedural approach to achieve these supernatural properties. "Chris devised a clever rig in Softimage that allowed us to take the motion capture of a human performance and map it over the CG character to drive the character's legs," related Jeannette. "In some cases we didn't use any motion capture at all, so we took a lot of footage and key-framed over the top. Mark Powers and



In the course of a wild chase, a soldier mummy gains access to a bus commandeered as an escape vehicle by O'Connell and his family.

David Weinstein, the animators on those shots, did a great job. They studied reference footage of ostriches, which can run thirty miles per hour or more. Ostriches don't have exactly the same leg architecture, but it was helpful as inspiration. We would use that reference as a starting place, then make the body more human in behavior."

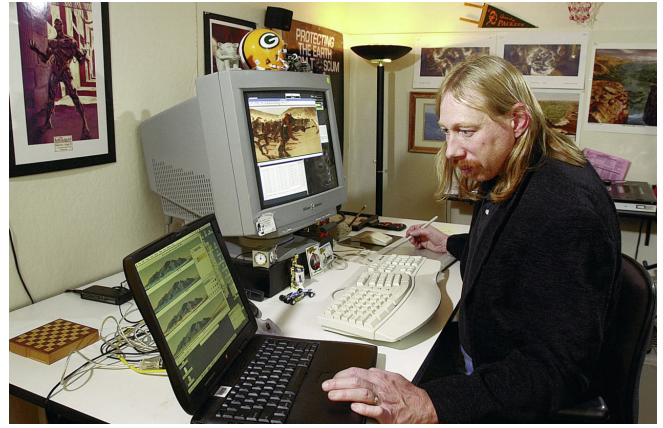
With design and previsualization work progressing at ILM, John Berton- accompanied by a team that included compositing supervisor Tom Rosseter and CG supervisor Kevin Rafferty- took off for Jordan and Morocco, where principal photography was slated to begin in mid-April 2000. "When we go out to a big overseas location, we usually have about eight people on set," asserted Berton. "In this case, we had a slightly larger crew because I had torn my Achilles' tendon and needed a bit of help climbing up hills and running across sand dunes."

The ILM crew included a complement of three match-movers, led by Marla Selhorn, whose task it was to record all of the data needed for tracking CG characters into the desert vistas. Annotations such as distance from the camera to a fixed point of a dune became invaluable later in production when the team faced background plates featuring scale-defying curves of desert sand. "We'd have someone stand out on the dunes with a stick," said Berton, "which we'd shoot from several different angles. We couldn't use laser photogrammetry systems to procedurally extract data because there weren't enough sharp points on a sand dune for the trackers to nail it. So we did a lot of building by eye when we got into post." Orthographic data also included photography of desert locations. The crew sent back digital stills and video to CG supervisor Robert Marinic via ILM's file transfer protocol site. Berton also shot thousands of 35mm images, using motion picture stock in a standard single-lens reflex camera, which were subsequently scanned and posted on the ILM internal website for match-movers and technical directors to reference.

A desert war opens the movie. Footage for the sequence combined plate photography filmed in Morocco with digital matte paintings, a miniature of the ancient city of Thebes and an army of two hundred extras digitally replicated into thousands. The clash of Akkadian and Sumerian forces results in a humiliating defeat for the Scorpion King, who swears vengeance and declares allegiance to the god Anubis, then snatches up a live scorpion and munches on the crunchy arachnid. Nick Dudman joined the location shoot in Morocco to provide the necessary edible animatronic for Scorpion King performer Dwayne 'The Rock' Johnson, a World Wrestling Federation star. "We built a number of half-mechanical, half-edible scorpion puppets for different takes," Dudman explained. "As The Rock brought the scorpion up to his mouth, its tail and legs were wriggling; but he was able to bite into it, making this goo come out. The front halves were made out of a thin shell of carnauba wax, which is what M&Ms are coated in. The interior was a special mix of ultraslime and food-grade yuck."

Anubis responds to the Scorpion King's oath by triggering the growth of an oasis out of the sand. The effect was realized digitally- by CG supervisor David Meny and technical director Ken Wesley- by mapping a background plate shot in Morocco with a growth algorithm that created ferns and grass and palm trees, animated to sprout on camera as the vegetation radiated toward the foreground of the shot.

The ancient Egyptian prologue concludes with the Scorpion King's return to power at the head of a new army of Anubis warriors which now lays siege to Thebes. In an epic battle scene, the camera tracks left to right with the onrushing army of dog-headed warriors, then scales the city walls and sails through the main temple plaza- a twenty-three-second shot achieved by blending the expansive Thebes miniature with digitally painted backgrounds, bluescreen live-action elements, motion capture and key-frame character animation, and 2D effects. "The attack on Thebes turned out to be even more complicated than the opening shot in the first film," commented Laurant. "I did a lot of research on ancient Egyptian architecture; but in this instance, I was informed by Allan Cameron's slightly more stylized take on the temples. He likes to take the real architecture and embellish it, making it a little more over the top." Taking his lead from a Cameron sketch, which portrayed giant plumes of smoke rising from the city, Laurant upped the mayhem in his own designs and created a digital animatic. "I built the attack shot to camera, using crude digital models to represent the rough sizes and positions of the buildings. We got fairly detailed in this animatic, adding a flow of Anubis warriors scaling the walls, obelisks toppling in the distance, smoke, battles in the plaza and a foreground structure for somebody to fall off."



Visual effects supervisor John Berton- a veteran of *The Mummy*- reprised his role for the sequel.



ILM modelmakers assemble a large miniature of ancient Thebes for a battle scene that opens the film.



Giovanni Donovan prepares hieroglyphic detailing for structures within the set.

Digital artist Aric Cheng refined Laurant's geometries in AutoCAD 2000, printing them as blueprints for use by the modelmaking team led by Barbara Affonso. "Miniatures are great for creating organic textures like stone," Laurant explained, "especially in a bright daylight shot like this one. Simulating that in the computer would have taken quite a while, so we decided to take advantage of the talent base in our model shop and utilize real light falling on real surfaces."

Over a period of nine weeks, Affonso and a crew of twelve constructed a 1/24-scale miniature of Thebes that covered a forty-foot-square area. Basic structures were made out of wood by Dave Murphy and Robbie Edwards. The main temple occupied a seventeen-by-eleven-foot area, stood ten feet high, and was surrounded by thirty-five feet of fifty-two-inch-high walls surfaced with a mixture of spackle and joint compound. A painting and texturing team, overseen by Lauren Abrams, created brick and plaster textures by scribing semi-dry plaster through etched-brass stencils and then adding hieroglyphic detail. "We had a lot of hieroglyphic panels along the side of the temple," Affonso related. "Normally, we'd sculpt, then mold and cast this kind of detail; but due to the quantity, we experimented by using our Computer Numeric Control machine, which is a computer-programmable mill." Working from flat artwork of the sculptural forms in the hieroglyphic panels, modelmaker Bryan Dewe imparted depth through the use of 3D modeling software. The CNC unit then engraved the results into half-inch-thick panels of medium-density fiberboard. Jon Foreman also programmed and cut hieroglyphics into layers of eighth-inch-thick masonite and applied these to the fiberboard around the sculpted forms. An Epson printer printed less prominent panels directly onto poplin fabric, which was wrapped around the temple columns. Statuary was sculpted and molded, then coated with dyes and colors that would seep realistically into natural fissures. Bluescreen backed the miniature, while smoke provided a layer of depth and scale. Added to the miniature photography was a far-distance, layered digital matte painting by Susumu Yukuhiro.

The final shot, teeming with Anubis attackers and their Sumerian victims, ends with a match-dissolve from ancient Thebes to a view of the same location in 1935- a digital matte painting by Jett, composited behind foreground elements photographed in Morocco.

Inside the now ruined temple, the O'Connells unearth the bracelet of Anubis and encounter a variety of physical and animatronic effects- shot on soundstages at Shepperton Studios in England. Using hydraulic rams, timed to topple by computer control, Neil Corbould staged the



Miniature plate photography- by effects cameraman Ray Gilberti- would be enhanced with hordes of live and digital combatants and other elements.

domino-style collapse of a number of huge columns for a sequence in which Rick and Evy make a narrow escape after snatching the bracelet. Nick Dudman and his creature crew furnished the setting with background tarantulas and a slew of scorpions to place among real ones featured in the scene. "We sculpted up some scorpions and cast a lot of them out of resin," explained Dudman. "Then we augmented them by buying up every black plastic scorpion the Republic of China had to export into this country. We put vibrating ball mechanisms underneath the sculpted scorpions, mounted on sheets, which gave them a little shimmer of movement. These were designed to have CG interaction on top, but they enabled us to give Stephen a decent background wherever he wanted to avoid CG." Dudman and team also created a number of animatronic snakes, seen only briefly in the temple sequence, but featured later when Imhotep's lover, Meela (Patricia Velazquez), threatens Jonathan (John Hannah) with one.

The story shifts to London, with Susumu Yukuhiro, Ivo Horvat and Kent Matheson creating nocturnal views of the city, with brooding clouds and flickering lightning, animated to simulate drifting camera perspectives. "Stephen told us he wanted London to look like Mary Poppins," recalled matte painting supervisor Rick Rische. "We weren't quite that stylized, but it was very romantic-looking. Ivo did a shot showing Saint Paul's Cathedral, Big Ben, Tower Bridge and the Thames- and nothing is where it's supposed to be."

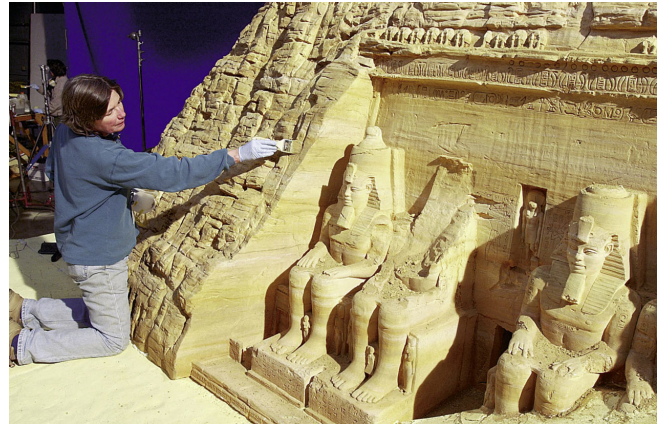
The matte painting team also created several flashback scenes depicting visions of ancient Egypt- first witnessed by Evy, then later seen by Alex as he tries on the bracelet of Anubis. The visions were a hybrid blend of 3D and 2D elements. "Wei Zheng created 3D models of the Giza plateau and the Temple of Karnac," related Rische. "He was assisted by Lou Katz, who handled the match-move and brought in additional 3D elements. Scott Frankel handled the compositing of magical elements, like light beams that came shooting out of the bracelet and accelerated clouds. It was a surreal effect, almost like you were seeing a holographic representation of Giza appearing inside this living room."

Action builds as Evy is kidnapped and slated for sacrifice at Imhotep's revival ceremony. Imhotep's resurrection scene, and earlier scenes showing his remains, called for the creation of the 'Imho-slab,' a special prop containing Imhotep's petrified corpse which- salvaged from his previous molten tomb- was now sealed into rock. "Stephen told us, 'Whatever you do, it mustn't look like Han Solo in carbonite,'" Nick Dudman remarked. "We did a series of sketches and decided, since the material that Imhotep appeared to sink into at the end of the last film was this black liquid, one could argue that if that solidified it might look very much like glass. The minute we had that idea, we asked, could it be translucent? This, of course, would be a nightmare for us, but we decided that it would be a lovely thing to do."

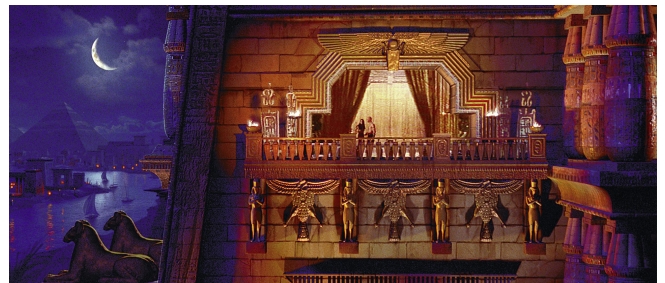
Sommers okayed the translucent concept and suggested a black-and-yellow color scheme, giving the impression that Imhotep had been sealed in amber. He also asked Dudman to give Imhotep the ability to subtly twitch before his full revival. Gary Pollard, lead artist on the project, began by sculpting Imhotep's shriveled corpse. Next, the body was molded and cast in resin; then an irregular, jagged rock shape was sculpted over this with a smooth, sheared-off section at the top. After molding this outer layer, Dudman's team began experimenting with the translucent appearance. A solid casting solution was deemed impractical- even a half-inch shell of clear casting resin weighed a ton, and was also impossible to polish. Instead, Dudman turned to a local manufacturer that specialized in making windshields for cars, and engaged them to generate sections of half-inch, optically clear thermoplastic material, which were then combined with a three-dimensional jigsaw of fiberglass and resin pieces. Pollard supervised the construction and cosmetic finishing, producing two versions of the Imho-slab, one solid and one fractured. "The slab behaved very nicely," stated Dudman. "Whenever you put a key-light behind it, you really got a glow from it." The subtle twitch requested by Sommers was supplied via simple cable mechanisms in The Mummy's toe and hand, which created a live-action beat of movement before the digital explosion and mummy resurrection took over.

Rick and friend Ardeth Bay (Oded Fehr) rescue Evelyn from Imhotep at the British Museum, where four soldier mummies materialize from an urn full of black sand. The resulting free-for-all leads out into the streets where the O'Connells discover that Jonathan and Alex have commandeered a double-decker bus as their escape vehicle. A hell-for-leather chase ensues, mummies assailing the conveyance, as the bus careens through nighttime London- a show-stopper sequence for Berton, Dudman, Corbould and Jeannette.

The soldier mummies were achieved through a variety of means. "Any time they're really moving, the mummies are likely to be CG," Dudman stated, "just because of the almost mechanical similarity in their movements. And, obviously, any time you really see through them, it's not a man in a suit. But for closeup action scenes, with physical interaction with an actor or the set, our prosthetics were used. So we found ourselves, once again, surrounded by mummies." The assignment included the making of full-body suits, as well as insert pieces fabricated by Karl Derrick. Neil Corbould provided mechanical gags such as a bus roof that



For a passage up the Nile, miniature supervisor Barbara Affonso adds finishing touches to the ruined Ramses temple at Abu Simbel.



A scene between Imhotep and Anck-su-namun on a palace balcony in the long-distant past was played out on a small set piece extended to grand scale by a digital matte painting.

peeled itself back as a digital soldier mummy gained entry and a rig to shear off the top deck of the bus as it hurtles under a low bridge. Dudman created a 'pizza mummy' splat on the wall, devised to stick and then unpeel from the bridge in the wake of the departing bus.

At the beginning of the sequence, Jeannette used motion capture for scenes of mummies giving chase and receiving shotgun blasts. From there, the animation literally took off into key-frame realms. "Stephen had a very strong audience reaction in the first film to the scenes where the soldier mummies climbed the walls of a cave," Jeannette stated, "so he wanted us to use that in the bus chase." David Latour animated acrobatic scenes with mummies scaling the British Museum walls, vaulting columns and landing on the moving bus. Victoria Livingstone handled closeup grappling scenes, including a fight between Ardeth Bay and the top half of a mummy whose legs have been torn away. Animators studied reference footage of actors running through their actions- choreographed by stunt coordinator Gary Powell- then used key-frame animation to add the legless mummy to plates of performers grappling with air. A match cut to a pyro-rigged dummy dispatched the marauder at the crucial moment.

Despite vigorous attempts to repel Imhotep's minions, Rick and Evy are separated from Alex. A quiet scene follows on an upper balcony of the British Museum, where the rejuvenated Imhotep, still in his desiccated form, takes Meela in his arms and reveals to her that she is the reincarnation of Anck-su-namun, his Egyptian queen. As they kiss- in a critical interplay of motion capture and live-action, with key-frame detail allowing Imhotep's fingers to caress Meela's hair- the scene morphs to Vosloo in human form



A multilayered composite of live and digital elements transformed a contemporary location in Jordan to 1935-vintage Cairo.

kissing Velazquez as Anck-su-namun. The camera pulls back to reveal the couple on an Egyptian palace balcony in the long-distant past. Rick Rische generated a digital matte painting for the scene by inserting footage of the actors on a balcony set piece into a 3D palace, then animating a reveal and creating the nearby Nile from video of a daylit river, tiled and color-corrected. With the addition of a moon reflection, river boats, distant fires and animated clouds, the final image was virtually identical to a production illustration provided by Allan Cameron.

Cutting back to 1935, the camera booms down from a view of the Giza pyramids to a train carrying Imhotep and the abducted Alex as they make their departure from Cairo- a four-layer composite of live-action filmed in Jordan, digital elements and stock photography of the pyramids. Wei Zheng produced the matte painting, which was composited by Julie Neary, who slipped backgrounds behind smoke from the train's smoke stack and added a parallax shift to duplicate the live camera move. The team also created a 3D replica of the train and further synthetic vistas of Egypt out of whole cloth, including a view of the Ramses temple at Abu Simbel, represented by a twenty-by-twenty-four-foot miniature crafted from urethane foam with pottery plaster statuary.

On board the train, Alex is brought before Imhotep and informed of his impending fate, while Meela deals with a group of low-life mercenaries who have procured the Scorpion King's

remains from England. Imhotep steps in to personally administer the mercenaries' reward, draining them of their souls and thus regenerating his body. The life-draining shots were realized through particle animation. "Stephen wanted a textural, non-luminous look to the life-energy extraction scenes," said Laurant. "I always noted on the designs we sent to the studio that all these scenes were to be played dry and sandy, not wet and gory. It was a way to be grotesque and horrifying, without scaring the studio."

Rick, Evy, Ardeth Bay and Jonathan are reunited with Izzy (Shaun Parkes), an O'Connell accomplice from the first film, who provides them with aerial transportation- courtesy of his own 'Magic Carpet Airways'- a fishing trawler hung beneath a weather-beaten dirigible. Neil Corbould created a hydraulic motion base, situated in front of a bluescreen, for live-action shots of the conveyance. "The original concept was to bolt the balloon into the roof," said Corbould, "then just have the trawler moving underneath. I suggested that we move the top as well, so we built two motion bases. We built a seventy-foot section of the underside of the balloon and mounted that to a rig up in the ceiling of the stage. Then we mounted the trawler to a rig beneath that and linked the two motion bases through our computer, so they moved together."

As Izzy's blimp enters the winding canyons of the Nile River Valley, Imhotep discovers that Alex has been leaving clues to help his father track their progress into the desert and sets a trap. Continuing the theme of extrapolating natural elements, Imhotep elects to attack his pursuers by wading into the river and conjuring the water to rise up at his bidding. The scene was photographed dry-for-wet in an arid canyon in Morocco, with Vosloo striding into a dry river bed. The entire river around him was generated months later at ILM. Subsequent scenes of water rising and crashing through the river canyons also featured plates of arid location photography in Jordan, composited with synthetic waves timed to churn and smash against the canyon walls. "We spent several weeks in Jordan, filming the canyons in Petra, basically using them as miniatures," said Berton. "The canyons were already two or three hundred feet tall, but we played them in the movie as thousands of feet tall."

As the raging tsunami bears down on the low-flying dirigible, an enormous image of Imhotep's gaping visage appears in the water- a key-frame-animated distortion orchestrated by Jeannette and Paul Griffin from a scan of Vosloo's face, echoing the visage that appeared in the sandstorm in *The Mummy*. Aside from accents of real splashing water composited to enhance scale, the water effects were a multilayered blend of digital fluid dynamics and particle simulations wrought by David Hisanaga, Robert Marinic and Amelia Chenoweth.

Before the dirigible crashes, it emerges from the canyon and O'Connell catches his first glimpse of the oasis of Ahm Shere, which now fills an entire valley and surrounds the Pyramid of Gold. The vista combined 2D and 3D elements, and set the look for all the views of the oasis that would



A fishing trawler attached to a balloon- achieved both digitally and with full-size motion base rigs- provides aerial transport over the desert.

follow in the movie's final act. "Paul Huston used a variation on the technique that he spearheaded for the pod race in *The Phantom Menace*," Rische noted. "He set it up by sculpting and painting rock sculpture pieces and photographing them outside in the sun from a variety of angles. Then he cyberscanned the sculptures, creating 3D digital versions, and mapped his photographs onto those. This gave him a photorealistic landscape to start from. For the oasis vegetation, all green and beautiful, Paul sculpted another fairly rough miniature of the terrain, detailed it with little trees and bushes, then also shot that outside in the sun. Once he scanned that into the computer, it gave him a topographical model of the terrain, which he combined with a lot of 2D photographic textures from Morocco and his own 2D artwork."

As darkness falls, both O'Connell's party and Imhotep's men continue into the jungle on foot, making for the pyramid. Surprises await, as evidenced by the remains of hundreds of rotted corpses littering the flora- the result of mass production by the Dudman crew, with some creative recycling from *The Mummy*. The human detritus foreshadows the discovery of a pale, misshapen figure, thirty-six inches tall. The creature appears dead and half-grown into a tree- until its eyes snap open.

Based on an ILM design by Derek Thompson, who produced a Photoshop composite of an armed horde of the creatures leaping from a gloomy forest background, the pygmy mummies- as they were known- were another fantasy concept drawn from Edgar Rice Burroughs tradition and Sommers' imagination. "Stephen had a soft spot for the pygmy mummies, who are the guardians of the Pyramid of Gold," Laurant related. "He wanted them to have the same desiccated treatment as Imhotep's stage one, but they're monkey-like in stature, very agile and aggressive."

Dudman created a sculpted, posable version of ILM's pygmy design, cast out of foam over a metal articulated skeleton. The dummy was featured in the discovery scene at the tree- filmed on a stage at Shepperton- but thereafter was used only as an on-set lighting reference for ILM computer graphics. "On occasion, we also had small people on set as action references," Berton commented. "Obviously, they weren't able to pole-vault through the air, land on people and skewer them, but they were great to work with because they really gave us a perspective as to where to position our cameras that we might otherwise have missed." ILM conducted early pygmy mummy motion studies using child performers in motion capture suits, but this approach was finally rejected in favor of key-frame animation, overseen by Colin Brady and Marjolaine Tremblay, with Indira Guerrieri supervising pygmy lighting, rendering and simulations.

The O'Connells regain their son, take leave of Ardeth Bay, then arrive at the base of the Pyramid of Gold- an expansive full-scale set built at Pinewood Studios, digitally extended by an ILM matte painting. Once inside, Rick discovers that Imhotep- now fully restored, but depleted of his powers- is about to revive the Scorpion King in order to usurp the ancient warrior's dark powers. Meanwhile, in the desert beyond the oasis, Ardeth Bay reappears with his Medjai forces- an army of thousands digitally replicated from fifty extras on horseback. The Medjai look on as a strange apparition appears before them, a giant dune turning black and disgorging Anubis warriors- a distortion map applied to 3D geometry of desert footage, combined with particle animation of thousands of digital Anubis warriors. As O'Connell and Imhotep face off in the pyramid, the conflict continues to play out above ground on a grander scale in a clash of live

and digital armies commingled by ILMCG supervisor David Meny and technical directors Henry Preston and Paul Sharpe.

“Any time you do a movie of this size,” stated Berton, “you look at Lawrence of Arabia, you look at Spartacus, you look at all the great battle scenes from Barry Lyndon– and we certainly did that for our Anubis battle. We put together videomatics that showed how our battle might be staged, and we choreographed the action to expand the scope as much as possible, regardless of the fact that we were dealing with Anubis warriors. Then we went to Morocco, which has miles of space, and shot for days and days.” Working closely with Gary Powell and second unit director Greg Michael, Berton plotted action using stand-ins dressed from head to toe in vivid bluescreen material, with metal extensions strapped to their backs to simulate Anubis eyelines. Medjai cavalymen were then able to charge and swing their weapons at their imaginary adversaries with conviction, occasionally being thrust across the screen themselves by mechanical devices and jerk-wires rigged by Neil Corbould.

Berton shot the battle plates in Vistavision to allow flexibility in framing during postproduction. To preserve spontaneity and energy in the shots, fights were staged in layers without motion control. At one point, Berton removed a Libra camera head from a helicopter mount and affixed it to a tripod to perform unsynchronized but repeatable passes– but the majority of shots were captured ‘wild,’ with fight performers timed to enact a variety of conflicts at different geographical points while the camera operator approximated the same particular pan or tilt. Vignettes of smaller fighting groups were also staged with the intention of adding them to the final enormous digital mesh.

“Tom Rosseter and his compositing team did an amazing job,” stated Jeannette. “Once they had painted out the bluescreen suits and rigging, Marjolaine Tremblay and I came in and started to look at how specific performances would fit.” Because there were so many Anubis characters, Jeannette and Tremblay employed motion capture wherever possible. In fact, Jeannette encouraged animators to perform motion capture sessions themselves, to give a better feel for the performances they were creating. “With the animator inside the motion capture suit, we would eyeball the action and emulate the fight. Then we could adjust the timing at the point of contact and often drop that in as a 2D element.” For closeup physical interaction of CG warriors clashing swords with live actors, animators employed key-frame animation, which gave more control of timings. For a scene in which Ardeth Bay beheads the last of the first wave of Anubis warriors, animator Tim Harrington found himself doing key-frame animation for three hero characters, a time-consuming task. Interactive effects, including sand spurting from Anubis wounds and atmospheric dust, completed the composites.

Back in the pyramid, O’Connell confronts the Scorpion King in his full mutated form: a towering half-man, half-scorpion minotaur. This final manifestation first evolved on paper. “A number of artists contributed different creative approaches,” noted Laurant. “Does he walk on two legs? How much of him is humanoid? Is he a human being with a big scorpion body? Is he a human being with scorpion claws? Does he have a scorpion face? We presented all of these ideas to Stephen, to see what he wanted from the point of view of character and storytelling.” Sommers selected a rendering by Derek Thompson that pictured a scaly human torso with powerful clawed arms rising from an eight-legged arachnid body with a stinging tail.

“Though there was less of a direct homage to Ray Harryhausen in this film than in the first one, the character of the Scorpion King was inspired by Harryhausen movies,” observed Daniel Jeannette. “We viewed some of the work that could be similar and then tried to create something that was really different. We looked at footage of real scorpions to study their movement, but real scorpions are so light and ‘flickery’ in their movements, we decided our character needed to be a bit more compelling and impressive. So scale issues and eyelines became critical while we were trying to determine how he related to our actors. We had to make sure that the timing of the camera moves and the framing were supporting what the character was supposed to be in the context of the shot.”

Berton and Jeannette decided to pursue an entirely key-frame approach to the Scorpion King finale and previsualized the action with digital animatics which they brought to set- a subterranean lair of steaming crevasses located in the base of the Pyramid of Gold, where O’Connell’s final duel plays out. “We put stunt guys on stilts, and they walked around at the correct height to show Brendan and Arnold where the Scorpion King would be,” related Berton. “We walked the actors through the shots, marking out spots where the Scorpion King stand-in should stand. We shot the stand-in as an action reference to help us determine camera moves and angles, but there was no way to mock in a creature like the Scorpion King on set without it becoming unwieldy. That was ultimately beneficial, because it placed our creature completely out of the realm of any living thing, which was exactly what we wanted for the ending of our film.”

Creature developer Aaron Ferguson and software engineer Sebastian Marino developed the Scorpion King character. Miguel A. Fuertes headed the team of animators that brought the Scorpion King to life, while Erik Mattson served as CG supervisor and Catherine Craig as Viewpaint supervisor. As plate photography arrived from England, the brooding look of Allan Cameron’s primordial lair set and Adrian Biddle’s atmospheric photography provided its own particular postproduction challenge. “There were



A clay maquette of an Anubis warrior, sculpted by Richard Miller as an aid to digital modelers, is critiqued by visual effects art director Alex Laurant and animation director Daniel Jeannette.



Ardeth Bay and his Medjai forces- digitally replicated from only fifty horsemen- prepare to do battle with an army of Anubis warriors.



The nine-foot-tall Anubis warriors were entirely computer generated.

flamethrowers on the set in every shot,” remarked Berton. “This created an interesting problem for the computer graphics team because the light sources were not only moving, they were moving in an uncontrolled way. A flamethrower makes a ball of fire, which travels across the room in a fairly unusual fashion. That gave us quite a conundrum to match our character to the plates; but ultimately, because our character moved so dramatically, the lighting really added to the drama of the scene.”

When O’Connell delivers a final blow, dispatching the Scorpion King, the desert battle is simultaneously affected– the Anubis warriors explode into black sand and the oasis begins to collapse as the Scorpion King’s lair starts to

self-destruct. After a brief hiatus, in which Anck-su-namun and Imhotep meet their separate dooms, Rick, Evy, Jonathan and Alex flee a rain of digitally enhanced falling stalactites. Computer Film Company in London supplied the approximately fifty shots. “It was a fair-sized sequence,” recalled Mark Nelmes, who supervised the addition of digital and miniature elements. “We added camera shake and dust to shots during the build-up to the sequence, then tracked twelve shots where the room was shaking violently and added 3D stalactites. We also built some three-foot plaster stalactites and shot them falling against bluescreen at Ocelot Studios in London. That gave us some dust passes and some nice gritty stuff when they hit the ground, which was useful for 3D.” Dominic Parker oversaw the CFC 3D work, with Paul Goodfellow and Louis Dunlevy, while Nelmes led the 2D team, occasionally adding atmospherics to ILM plates in the Scorpion lair as the oasis implodes.

“The oasis was an area, ostensibly, five miles wide and twenty miles long,” Berton commented. “We decided that the only way to suck all that down into a single point– collapsing all the greenery and the entire jungle, leaving nothing but sand– was by using procedural computer graphics. It was the only way we could control that much information. The sand was a combination of elements filmed in Morocco and paintwork done at ILM, but all of the trees, the entire forest, the golden pyramid at that point were synthetic. We employed procedural animation technologies with particle system simulations, using trees and various other kinds of foliage as particles, with everything controlled by these enormous forces. In a way, it was an exciting parallel to what we were trying to show: the idea that there was some magical force pulling everything right down. We just used a mythical mathematical force to pull all the computer objects down.” Erik Krumrey and Robert Marinic headed the technical team, working from the master digital matte painting created by Rick Rische and Paul Huston.

Ascending to the summit of the pyramid– a set piece built at Bovingdon Airfield, outside Hemel Hempstead in Hertfordshire, England– O’Connell and family are greeted by Izzy’s dirigible, a crane-mounted piece, flown on set by Corbould. They clamber aboard as the pyramid vanishes beneath them and, with a final salute from Ardeth Bay out in the desert, sail off into the setting sun.

From its inception as a screenplay to the crossover of design work between Industrial Light & Magic and Allan Cameron, *The Mummy Returns* stands as an enormously collaborative effort. “ILM is really no longer a postproduction house,” Alex Laurant observed. “It is true for us and many other visual effects companies: the more integrated we become with production design

before the cameras roll, the more complete environments and characters we're able to generate."

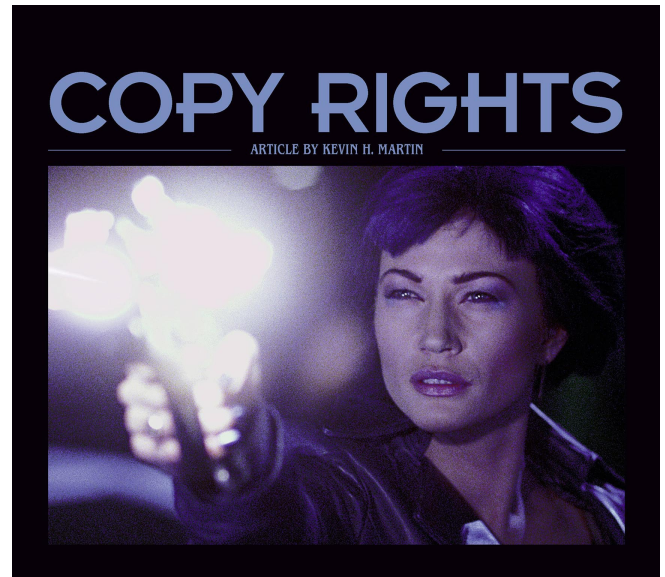
The integration of visual effects into the production process also spawned mutually beneficial relationships with the actors. "Nothing pleases me more than to have a principal actor in the middle of a visual effects scene," John Berton remarked, "because the audience is drawn into the movie by his characterization. If that character is faced with some great issue in the film that's generated by a visual effect- whether it's a monster or some huge spectacle- if he's interacting with that effect, he lends his credibility and really elevates that illusion. Brendan was fantastic in his understanding of that. We'd explain to him what it was we needed and he'd make sure it worked. When you get that into the plate, well, you're halfway there."

Ultimately, the insistence upon 'bigger, better, bolder' resulted in a sequel that reinvented the first film as much as that first film had reinvented the Boris Karloff classic. "We were striving to create something that would bring to audience members' minds what they liked about the first movie," concluded Berton, "with characters they remembered and wanted to see more of, but with new elements that would create the same feelings of amazement. I think the first film took people by surprise. There were certainly horrific things about it- as there are with this one- but people were pleasantly surprised that it was such an invigorating and spectacular film. This time they'll be expecting just another sequel. Our feeling now is: 'Okay, you'll get that. But we're also going to bring you a movie that's going to leave you just as flabbergasted as the first one.' More so, we hope."

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In his series of “Eight Worlds” stories, novelist John Varley postulated a future in which murder would become a lesser felony as a result of technological advances that allow the dead to be re-created physically, then have their total life memories downloaded into the new body. Since the process allowed for easy restoration of life, it also effectively cheapened the value of it, causing the penalty for homicidal actions to be downgraded.

Even if the technological breakthroughs could be achieved to make such a process practical and cost-effective, there still remain questions regarding the ethics and legitimacy of the approach. Are biological heritage and memory enough to re-create a person fully? Is there an intangible aspect- what the spiritually-minded might call ‘soul’- that would defy such replication? Would a re-created person who seemed identical to his predecessor in every way to the world around him, and even to himself, in fact be the same- or would this new lifeform be merely a copy, at some measure removed from the original? And what if one or more duplicates were made of someone who was not dead? Would the original have ‘squatter’s rights?’

The 6th Day, a Phoenix Pictures production released by Columbia Pictures, explores some of these same issues. In the movie’s near-future time period, cloning of dead pets is a fairly routine event, as is the duplication of fish and other livestock to create supplemental food sources. But the cloning of people is strictly forbidden under the ‘6th Day’ law- a reference to the Book of Genesis and God’s creation of man ‘on The Sixth Day.’ Inadvertently drawn into a dispute between cloning giant Replacement Technologies- headed by Michael Drucker (Tony Goldwyn)- and a network of eco-terrorists opposed to clandestine aspects of that company’s work, charter pilot Adam Gibson (Arnold Schwarzenegger) comes home on his birthday, only to find another Adam celebrating the event with his wife Natalie (Wendy Crewson) and their friends. Realizing that illegal cloning must be involved, Adam goes on the run from Drucker’s minions- intent upon killing him to erase all tangible evidence of the company’s human cloning activities- thwarting and dispatching the same killers again and again, as they are re-cloned after each failed attempt. When Natalie and daughter Clara are kidnapped, the two Adams team up to rescue their loved ones.

After gaining Arnold Schwarzenegger's interest, Phoenix chairman Mike Medavoy engaged director Roger Spottiswoode to helm the project. Lions Gate Studios in Vancouver was selected as home base for the production, though the filmmakers also utilized practical locales in the city and made an excursion to Toronto for a shopping mall scene. To look after the film's visual effects needs, Phoenix and Spottiswoode hired visual effects producer Karen M. Murphy, who in turn brought David Drzewiecki onto the film. Originally enlisted as visual effects director of photography, Drzewiecki soon became the film's visual effects supervisor, attending to effects requirements during the main-unit shoot, while also gathering data that would be used in postproduction by a variety of visual effects houses.

The world of *The 6th Day* was based in part on what could be achieved using existing locations with minimal modifications. Although originally conceived to take place twenty or more years in the future, the time period was eventually changed to an unspecified near-future that could be realized with greater economy. Conceptual illustrator Ron Cobb aided the production design team- headed by James Bissell and John Willett- in envisioning the film's futuristic elements, developing a hybrid helicopter/jet plane, called the Whispercraft, as well as advanced weaponry and vehicles.

Isolve, a Seattle company founded by Richard Lupton, created monitor graphics for the picture. "Rick came onto the show very late," Drzewiecki recalled, "so to keep production properly supplied, he wound up working incredibly hard all through the shoot, often around the clock without sleep. Rick oversaw recording and playback on set, while also getting hands-on with the creation of some of the graphics and supervising others doing the same. He established a look for all of the corporate stuff, suggesting a near-future world, then produced volumes of the stuff, which had a very consistent high-quality look." Replacement Technologies lab sets featured the Isolve graphics, as did automobiles, Whispercraft and futuristic hand-held props with display screens.

Costuming and makeup achieved other subtle hints of the future, suggesting altered styles and tastes. "Roger wanted a small percentage of people to look a bit bizarre- futuristic but not wildly so," commented makeup department head Jeff Dawn. "We played a bit with high fashion, hiring gorgeous models and clothing them in provocative outfits to create Barbarella-type looks for some background players. It isn't in-your-face at all, but occasionally someone passes through frame that makes you realize this isn't your local galleria."

Dawn coordinated the makeup efforts in both Vancouver and Los Angeles. "Whenever I'm going to be on location, I try to find a local lab," remarked Dawn. "It can be a difficult sell for production, because usually they've already hired someone from L.A.; but I explain to them that there are always going to be changes, and someone will be needed on location to accommodate those. I used Bill Terezakis- a top lab technician in Vancouver- for foam, silicone and gelatin appliances that had to be made quickly. My on-site testing up there was done with Charles Porlier- who had been my right-hand man on *The Thirteenth Warrior*- plus two other local guys, Brad Proctor and Jason Palmer."

Before venturing north, Dawn contracted with Mike McCracken, Jr., to produce a variety of foam latex appliances, including a large number for the film's stunt doubles. "We went through

about eighty of those just on Arnold Schwarzenegger doubles,” Dawn affirmed. “Foam was the only way to go with these appliances, since the guys would be sweating, flying through the air and running in rain all the time– nothing else would have held up.” From his longtime association with Schwarzenegger– the upcoming Collateral Damage being their eighteenth outing together– Dawn had developed a strategy of enlisting stunt performers who bore a physical resemblance to the actor. “If you’re already in the ballpark, looks-wise, then adding some prosthetics and hair work will get you a very close match. That’s why I always push for good doubles. I have a book of images to show each director in support of this approach; and almost always they get very excited by the possibilities, as do editors and second unit directors, because it lets the camera get in closer and hold longer during stunt actions.”

The 6th Day gets underway with a brief history of cloning, ushering us past recent real-life events, such as the birth of Dolly the sheep, and into the near-future, when cloning of animals is not only commonplace, but a going concern. Spottiswoode had already hired Digital Kitchen– a Seattle design firm known for its commercial spots– to create a look for the movie’s memory-implantation scenes, and elected to have the same group generate imagery to support the opening expository sequence. Digital Kitchen creative director Paul Matthaeus began by allowing his staff of designers to develop a variety of possible looks. “We then culled the best approach,” Matthaeus explained, “assigning that designer as production lead for the sequence. The history-of-cloning assignment reminded me of the openings of Star Wars and Blade Runner, since a considerable amount of information needed to be conveyed. We were able to enliven that exposition graphically by dealing with genetics. We begin at the atomic and cellular level, revealing past scientific discoveries; then we head out into the future everyday world, where we depict how technological advances have manifested themselves, both with respect to political issues and to lifestyles.”



In the science-fiction thriller, *The 6th Day*, pilot Adam Gibson (Arnold Schwarzenegger) discovers that he has been illegally cloned, triggering an attempt by culprits at Replacement Technologies to terminate him. Early in the film, Gibson and partner Hank Morgan (Michael Rapaport) test a new remote control system for flying one of their charter company’s Whispercraft. In-flight scenes of the high-tech planes employed CG models animated by Rhythm & Hues.

The film proper opens at a football game, where huge holographic projections of star quarterback Johnny Phoenix are seen revolving against the roof of a vast domed stadium. The stadium plate- shot during a Canadian Football League game- was the very first production footage exposed for the film. Live-action for the quarterback hologram was shot later by Dave Drzewiecki. "We wanted four Johnny Phoenix heads, each at right angles to the others," Drzewiecki commented. "The idea was that each head would be mouthing the same public service announcement simultaneously to all four corners of the stadium. I put the actor on a motion control rotator and shot him four times against bluescreen, offsetting him ninety degrees each time. We had him lined up to ensure all four of the heads met at the center point of rotation for each take, so they'd be revolving around a common axis. To keep the heads all speaking in unison, we had prerecorded the actor reading his line; so during each take, he just lip-synced to the playback."

Creating a holographic look for the bluescreen element and compositing it into the stadium background fell to Visual Concept Entertainment. "The idea was that these holograms would bend light somewhat," observed VCE visual effects supervisor Peter Kuran, "causing distortion in the area of the plate being occluded by the virtual character. It's an effect that reads best against a detailed background, which was the case with most of the holograms we did on the show. For the stadium scene, however, the dome is pretty dark, so the distortion doesn't register as vividly."

The movie introduces pilot Adam Gibson at his home, where he is picked up by his partner Hank Morgan (Michael Rapaport) and driven to their air charter service. Once there, Adam demonstrates a new hand-held remote control for operating their charter fleet of Whispercraft- futuristic conveyances that are equal parts helicopter and jet plane- which have rotor blades that retract into wing-like forms for extra speedy flight.



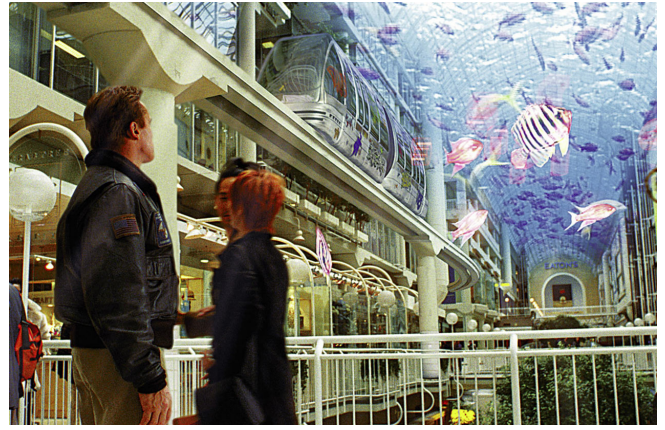
In the science-fiction thriller, *The 6th Day*, pilot Adam Gibson (Arnold Schwarzenegger) discovers that he has been illegally cloned, triggering an attempt by culprits at Replacement Technologies to terminate him. Early in the film, Gibson and partner Hank Morgan (Michael Rapaport) test a new remote control system for flying one of their charter company's Whispercraft. In-flight scenes of the high-tech planes employed CG models animated by Rhythm & Hues.

Special effects supervisor Michael Lantieri constructed two full-scale Whispercraft mockups for the production. An early shot of the mockup on its landing pad required postproduction enhancement in the form of revolving rotor blades. Digital artists at Rhythm & Hues, overseen by visual effects supervisor Tom Leeser, created the 3D CG element, which required careful integration into the plate. "Pierre Mignot, the director of photography, shot the scene hand-held, with a really wide lens," Leeser recalled. "This was a Super 35 show that would be releasing in anamorphic, so there was a lot of aberration, creating a radial distortion. We did a track and tried applying it in a normal 2D environment; but that didn't work, so we took it into the Inferno and added bicubic distortion to the element being tracked in." The approach afforded R&H a variety of options for image manipulation and correction, as each bicubic sheet- a deformable mesh form- featured sixteen separate control points.

In addition to producing blade-element geometry, Rhythm & Hues had to doctor the plate background. "There was a whole cityscape in motion behind the Whispercraft during this camera move," said compositing supervisor Cheryl Budgett. "As a result, we had to replace any background occluded by our blade elements. Plus there was a lot of roto on the foreground, since Hank and Adam are out in front of the aircraft. The original plan for the blades was to show them slowing down in a brief twenty-frame cut- but it wound up running three hundred frames. As a result, although it was one of the first shots we got, it was among the last to go out."

In an early scene, Adam and Hank take to the air in one of their Whispercraft and embark on a hotdogging chase of an unmanned sister ship being flown by Adam via the new remote control system. Although Dave Drzewiecki, Jim Bissell and Michael Lantieri had lobbied for a motion control miniature to augment the full-size Whispercraft mockup, the production elected to realize the futuristic aircraft through digital means at Rhythm & Hues. "My experience dates back to opticals and model work," commented Leeser, "so it came as a surprise to me that Roger wanted to do the Whispercraft digitally. In other films, there are a lot of CG objects shown at night or in the rain, but this aircraft was going to be seen in daylight, so there was nothing for us to hide behind." Development of the CG Whispercraft proceeded from blueprints, as did the mockup. In Vancouver, Leeser made note of changes to the full-size craft. "At various stages of construction, I would photograph the mockup, then send those images down to R&H using a DSL line. Our modelers incorporated the changes, and we were also able to use the stills as guides for texturing the digital model, which employed 4K, 2K and 1K maps."

To define the Whispercraft in flight, Rhythm & Hues had to take into account the variable geometry of its rotor blades and wings. "Most of the time this ship looks and flies like a



For scenes in a futuristic shopping mall, digital artists at Cinesite enhanced footage of an actual mall in Toronto by adding a CG elevated tram and overhead holographic advertising.

helicopter,” R&H lighting director Alberto Noti remarked, “but sometimes it behaves like an F-16. Accommodating the very different actions associated with these two types of craft was difficult, since everyone knows how each performs in the air. Ultimately we had to declare new rules of flight for the Whispercraft.” Roberto Smith and Glenn Ramos co-supervised animation of the craft.

Working in concert with Leeser, aerial director of photography Bruce Dorn had shot custom plates for the passage through snow-covered mountains and canyons– but erratic Canadian weather conditions created matching problems. “Taking an overall approach to color-correction wasn’t an option, given the range of lighting conditions,” remarked Leeser. “Instead we had to treat this like a commercial, performing scene-to-scene color-correction for the entire daylight sequence– which involved quite a lot of cuts.”

The CG Whispercraft underwent a similar matching process to achieve the appearance of occupying the same environment as the backgrounds. “We initially considered a radiosity approach, but the render times were too high,” Noti commented. “At the other end of the spectrum, the simple environmental reflection techniques included with most software packages wouldn’t do enough for us. The ideal would have involved building 3D mountains and canyons to capture the environment, but we didn’t have enough information from production to do that, and it would have been extremely time-consuming. So instead, we faked a 3D environment using the only information we did have– the plates themselves.” The Rhythm & Hues team created six different maps from the background plates, which could be ray-traced and projected onto the Whispercraft. A bonus of this approach was the nearly automatic accumulation of interactive lighting. “When the Whispercraft raced over a river, we’d get some lighting from the water portion of the plate playing against our model; and this helped us with window reflections, as well. When the ship went between two walls in a canyon, however, the plate would be much darker. We couldn’t pick up much in the way of real lighting in those situations. That was also the case with some of the more overcast plates, which made for a flat lighting scenario that didn’t allow our CG objects to look their best. In those instances, our lead lighters, Michael Conelly and Art Jeppe, would cheat things to get a little more volume from the lighting than you’d have seen in reality.”

In addition to the plate-based lighting, other layers included a ray-traced pass of the ship, a reflection pass and separate passes for the Whispercraft body and blades. “We combined those passes in different ways,” Cheryl Budgett said, “depending on how dense the blade was supposed to read, which related to differences in day and night environments. We also worked a lot on contrast levels and edges of the Whispercraft to get good integration into the environment.”

Cockpit interiors were shot bluescreen, but the process was less than straightforward. “We wound up breaking all the rules of shooting bluescreen,” Dave Drzewiecki stated, “at least those with respect to carrying depth-of-field. In general, a successful composite needs deep-focus foreground live-action. Otherwise, you might have the extreme foreground of the live-action sharp and the composited background sharp, but find the live-action midground soft– either that or you wind up with fuzzy blue or black edges. But sometimes, when matching to the main unit’s work, I was stuck and had to adhere to their shallow depth-of-field. To get around

that, I produced a background element that was also soft, and that continued the look of what they got on set. During shooting, people are usually agreeable to this idea; but in post, it can turn into a 'why isn't the background in focus?' kind of thing. So, whenever possible, I light to keep everything sharp."

While some of the Whispercraft interiors were done with the canopy glass in place- allowing instrument light reflections to be captured- in other instances it had been removed to avoid bluescreen contamination. "For those occasions when the interior was shot without glass, we had to come up with a treatment to rebuild it in Inferno," said Tom Leeser. "I had taken a lot of cockpit still shots, so we were able to mix those in to reinstate reflection imagery. For views outside the mockup looking in, we mapped landscape plate footage onto the canopy to create exterior reflection elements."

Adam receives a call from his wife, informing him that the family dog has died and asking that he have it cloned before their daughter finds out. Though resistant to the notion, Adam is persuaded by Hank, who has a cloned cat, to look into it. In Adam's stead, Hank flies their next client, Replacement Technologies honcho Michael Drucker, to a remote mountaintop destination; but upon landing, both men fall prey to an eco-terrorist assassin opposed to the cloning company's illegal practices. Adam is next seen in a shopping mall, somewhat disoriented and seemingly unaware of how he got there. As he makes his way through the sprawling center, a tram zips past above him and a holographic advertisement plays out in midair. Cinesite created both the ultramodern conveyance and the hologram. Co-visual effects supervisor Thomas J. Smith began work on the project, but was soon called away to supervise Red Planet. Months later, he would return to The 6th Day, but in the interim Jerry Pooler was brought on to supervise. "We were given some stills of the location and asked to do some concept work," Smith explained. "The idea was to further futurize the Toronto mall, which had a unique design to begin with."

Cinesite art director Lubo Hristov did concept work for the tram, while staff modelers working in Alias produced it as a digital construct. "The path of the tram began at the edge of the frame in the plate, where there was a lot of distortion," recalled CG supervisor Lynn Basas, "but that distortion lessened as the tram continued on a very straight path back and away into the distance. The warping in the plate had to be simulated on our end- either with our model or with the camera- to get a good meld between the digital tram and the plate background." Lighting for the tram was done largely by eye. "We didn't need much in the way of chromed spheres on set for lighting reference, even though there was a lot of glass in the scene. Lighter Dylan Robinson handled that aspect of development for the tram,



Visitors entering the Replacement Technologies corporate headquarters are welcomed by a giant holographic greeter, a live actor digitally treated and composited into the footage by Cinesite.

dealing with reflections as well as localized lighting that our tram passed through. Tim Gibbons composited the shot.”



Relaxing at home, Hank Morgan summons up his virtual girlfriend, a holographic virtual construct. Greenscreen footage of actress Jennifer Gareis was processed by Visual Concept Entertainment and composited in live plate photography.



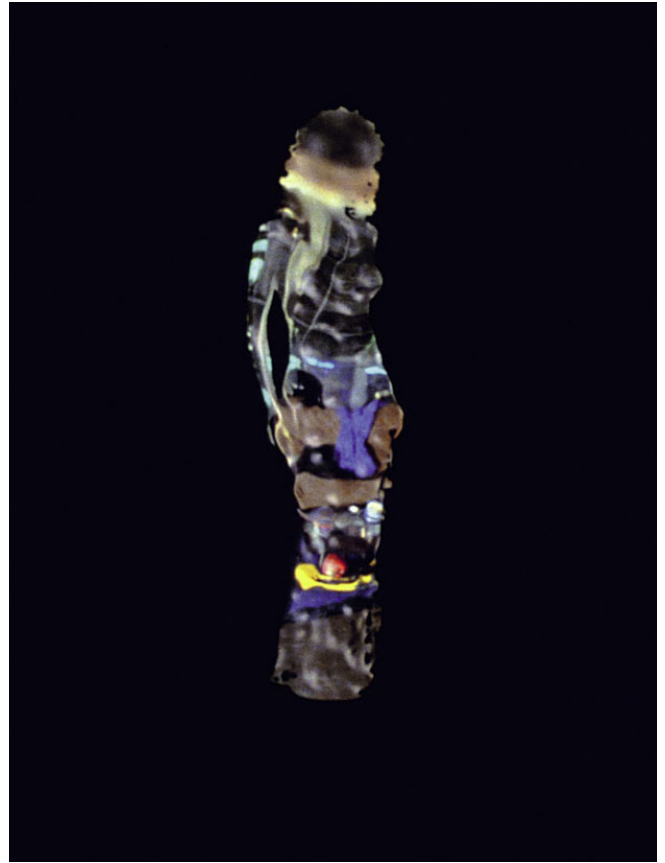
Relaxing at home, Hank Morgan summons up his virtual girlfriend, a holographic virtual construct. Greenscreen footage of actress Jennifer Gareis was processed by Visual Concept Entertainment and composited in live plate photography.

A spectacular light show on a covered street in Las Vegas served as inspiration for the holographic advertisement seen within the mall. "Although we weren't looking to do anything in that vein, the idea of changing a large overhead space into something really eye-catching was too good to pass up," Tom Smith related. "This was all being seen against the mall's curving glass roof, which extended far back in the plate. We started with the idea of having fish and clouds floating through the mall, with the advertiser's logo rotating in the middle of it all."

The holographic ad combined plate imagery of the Toronto mall with stock footage and 3D digital elements. "We started off by using stock footage of fish," said CG supervisor Dave Altenau. "We pulled a variety of keys on schools of fish, then blended the perspectives to recede so they worked for our camera angle. Then we augmented the stock image fish with hero fish done in 3D, and animated some of those so they seemed to pop out of this ad space right at you. To give the 3D elements a bit of extra kick and glow, we put in some luminescence while rendering, which gave more of a light-emitting, translucent aspect to these forms."

Adam crosses the mall and enters a RePet store to inquire about cloning his dog. On pedestals outside the store are two huge holograms of the company founders. "The RePet holograms were supposed to be about twenty feet tall," Jerry Pooler recalled. "To make them look even more striking, we worked on the plates of the actors playing the holograms, adding some volume that took the 2D curse off them and gave the impression that these projections had mass. They still read as somewhat transparent, but we were able to introduce mattes that could be animated separately, suggesting a voluminous liquid interior that displaced aspects of the original 2D photography. The actors had been shot from very low, looking up, which worked well for the liquid volume look, since the comp set them against the sky, which comes through as a strong backlight on them."

Instead of acquiring a replacement clone of the family dog, Adam purchases SimPal Cindy, a disturbingly lifelike doll that Clara has been urging him to get for her. Amalgamated Dynamics Incorporated built a series of puppets to represent the doll. "We were really excited at the chance to do a toy of the future," said ADI co-founder Tom Woodruff, Jr. "It was a matter of looking at the somewhat reactive toys of today- like Furbies and other gadgets that respond to voice commands- and taking them to the next step, which meant retaining the look and performance of an articulated toy, but making it much more realistic in appearance. But we



Relaxing at home, Hank Morgan summons up his virtual girlfriend, a holographic virtual construct. Greenscreen footage of actress Jennifer Gareis was processed by Visual Concept Entertainment and composited in live plate photography.

didn't want to just make a living girl up as a doll, because that would have been going too far, suggesting a technology more like the cloning process, which had to be a thing apart. Cindy had to seem hyper-real- but artificial."

Roger Spottiswoode had found a young girl who embodied the exact look he wanted for the doll. ADI took a lifecast of the girl, then did some resculpting before making molds and producing a translucent silicone skin. "We had to change our mechanical systems so we could drive a plasticized material," said Woodruff, "but that all worked wonderfully on a technical level." On an aesthetic level, however, concerns arose about Cindy's appearance- stemming largely from fears that she might come off as a distant relation of the evil Chucky doll seen in the Child's Play features. "There was something chilling about how she looked. The little girl was really cute, but her look was so extraordinary that she seemed too perfectly doll-like. Once we added the artificial eyes and translucent skin, there was something very unsettling to people about the idea that anyone might bring a plaything like this into your home. But in a way, that worked for the movie, because it reinforced the issues of identity and what constitutes life. If a toy can exhibit characteristics that are this lifelike, what does that say about the human clones?"

The ADI hero puppet- accompanied on set by mechanical designer Seth Hays- was capable of full facial articulation, including eye movement and blinking action, jaw movement and lip articulation. The latter used a computer-controlled synchronized playback system developed by ADI for the android Bishop puppet in Alien 3. "We preprogrammed the dialogue so lip-sync could be actuated on set with the touch of a button," said Woodruff, "but all the other aspects of her performance were puppeteered live. That allowed for some very good interaction between the doll and the actors in the scene, which was important. Too much preprogrammed action can destroy spontaneity."

Returning home with the doll, Adam peers in through a window and finds a duplicate of himself celebrating his birthday with family and friends. Before he can enter and confront the double, Adam is waylaid by Drucker's thugs. He fights them off and flees in his car, but his pursuers follow in a van, firing on him with laser-like weaponry. Ron Cobb designed the firearms, dubbed 'foosh guns' because of their distinctive sound, while Applied Effects constructed them.

"We used computer models to rapid-prototype the master guns," said Applied Effects co-owner Erik Haraldsted. "At this point, just about any file from a 3D modeling program can be translated into a physical model. We did main castings in aluminum, then produced bronze detail pieces." Each of the gas-actuated gun props- which spat plumes of flame from the sides of its barrel- was a self-contained unit capable of firing eight to ten shots before needing replenishment.

Visual Concept Entertainment created the look for the foosh gun beams, and also provided a large number of shots, though ultimately the volume of cuts- which increased from seventy to



During a virtual lovemaking scene, VCE imposed a distorted image of Morgan onto his girlfriend's back to impart a sense of prismatic transparency.

more than two hundred- led to Rhythm & Hues and Cinesite being assigned some of the foosh gun shots. "The beams needed to look like they passed effortlessly through objects and people," remarked Pete Kuran. "For a few shots, Roger wanted the look accented, so we'd show a bit of trail on the beams in those instances." The practical guns had spat yellowish flame, which was not in keeping with the concept of the foosh gun beams being blue-white hot, so the color of these fire elements was altered to blue while the beam was added. "We also had to change the color on the yellowish interactive light spilling onto set walls from the guns. The pyrotechnic hits done on set also had yellow flame, and we struck a balance on those. While the beam was on, we would color the hit blue; but then, after the foosh had hit, we would let the pyro go back to its natural warmer color. That let us avoid keeping an artificial lighting effect on screen for too long. We also had to synchronize the gunfire with on-set pyro hits, sometimes pulling the hit off the plate and putting it back in with better timing."

Turning eighty-plus foosh cuts around in only three weeks, Cinesite created the shots seen during the car chase between Adam and his pursuers. "This was my first CG supervisory position," Lynn Basas admitted, "so I was nervous about getting so many shots through in such a short time frame. But tracking pushed them all out in a week and a half. Our pipeline developed from one master setup, so the two foosh animators could reference that to determine where the beam should go and how long it should be; but we also had enough flexibility to be able to change scale, making the beams bigger or brighter."

More than foosh beams were altered during this process. Since the actors' aim was not always dead-on, Cinesite changed weapon orientation in shots where the squib hit was visible in frame and the gun was not properly aligned. "We'd rotate the gun arm and wrist slightly to get a good lineup before adding the foosh shot," Jerry Pooler commented. "We also wound up changing the direction of some shots that came right at camera, to get more perspective on the beam. Otherwise, they'd have just read like a tiny dot getting bigger."

The chase does not go well for many of Adam's attackers. One named Talia Elsworth (Sarah Wynter) is blasted in the neck by foosh fire. To produce the desired charred effect digitally, Cinesite tracked in replacement sections for her skin and body, combining geometry with textures to achieve a blend with the live-action plate. Talia is taken back to the Replacement Technologies cloning laboratory so that a clone of her can be produced to resume the search for Adam. ADI produced a full-body replica of the actress for shots of her dead form, though the company's principal responsibility was for the large quantity of clone blanks- undifferentiated human forms- seen floating in liquid-filled tanks at the center of the lab. "This was our first work on the show, and when we came in, there wasn't much in the way of prep time," Woodruff said. "We got to sit down and talk about the concept of these clone blanks with the director, which was great- since nothing had been done, we didn't have to work with anybody else's concepts. The only thing they were set on was that the clone skin should show the kind of translucency that turns up in endoscopic photography. That sounded exciting, since we always like to push further into that realm, to make things look that much more organic and lifelike."

The challenge for ADI was to evoke the look of an embryo, then realize that in a more-or-less grown human form. "The clone blanks are waiting for DNA injection, which provides the final imprint that enables them to grow quickly into a specific person," Woodruff explained. "We kept

the impression of a shape within the skull that corresponded to where the eyes would form, but didn't actually include eyes in the design. We had to devise median-sized clones, since they could be used as a basis for generating people ranging in height from Sarah Wynter to Arnold Schwarzenegger. Ultimately, we ended up making sixteen different body blanks in two sizes – five feet and four feet in height, just to break up the look and suggest a growth process that went beyond being stamped out like a cookie cutter to something more organic.”

With the clone blanks spending much of their time immersed in liquid, the choice of construction materials was limited. “We opted for silicone, as is our usual preference,” observed Woodruff. “While costly in terms of both material expense and time spent molding and casting pieces, the product has a lot to offer, with a look that is hard to rival using foam or other opaque materials.” As a final cosmetic touch, ADI fashioned birth-sac forms around each clone blank. “These had the feel of a thin gelatinous web– which created a resonance with the look of an amniotic fluid sac that you’d see in a real birthing process.”

The figures also required internal armatures. “We had to be able to lock the clones into different postures,” Woodruff reported. “They’d remain in a tight, body-clutching fetal position while floating in the tank; but later on, the tank explodes and they had to be loose-limbed while spilling out onto the floor of the lab. The armatures had lockable joints at the elbows, knees and hips and shoulders, but accessing them became complicated, because we had to be able to go through the clean naked skin of these fake bodies to tighten or loosen the joints. We wound up cutting slots in the silicone skin at natural crease lines, like the back of the knee, and in wrinkled areas, so we could slide our wrenches in there to get at those joints.”

The transformation from clone blank to Talia was achieved via Cinesite’s morphing of various elements shot motion control by the visual effects unit. “The original idea was to shoot a pass on the clone blank, then shoot another of the actress, and represent all the in-between action digitally,” Jeff Dawn stated. “But Dave Drzewiecki and I felt that more was needed on set– that the sequence would be enhanced through shooting practical elements for the in-betweens– and we finally got an okay from production for Bill Terezakis to create some silicone heads. Dave then photographed those so we’d have an interim form between ADI’s blank and the final human.”

To afford Cinesite more options in doing their morphs, Drzewiecki shot numerous passes for each clone transformation. “We had three cuts of one transformation and two cuts of another,” recalled Drzewiecki. “All together, there were fifty motion control passes.” Cinesite’s clone morphing– which utilized both 2D and 3D approaches to depict eyebrows and eyelashes growing in, eyelids opening, veins rising and other facial features forming– was spearheaded by Elastic Reality artist Mark Lewis, who, with Tom Smith, came up with transitions that worked well within the cut sequence.

Having dispatched most of his attackers, Adam goes to the police to file a report. Later he speaks with a holographic virtual attorney who morphs into a virtual psychiatrist after hearing the pilot’s crazed tale– more VCE-processed plate imagery– but gets little satisfaction from either. A recloned Drucker goon named Wiley (Rod Rowland) comes after Adam outside the police station, but the pilot kills him– again– by breaking his neck. To make his way past police

officers who come upon them, Adam lifts Wiley onto his shoulder and carries him, passing him off as drunk. For the scene, ADI made a floppy, articulated Wiley dummy, embellished to accommodate a Spottiswoode inspiration. “During a meeting, Roger came up with an idea he thought was hilarious,” noted ADI co-supervisor Alec Gillis. “While Adam is talking to the police, the dead guy’s tongue comes lolling out, together with a big wad of spit. Then Adam has to stuff what Roger called the ‘extend-o-matic’ tongue back into his mouth. We installed cable articulations to manipulate the tongue and built drool tubes for the saliva effect. It turned into a nice little add-on for us, and generated lots of laughs.”

Adam visits Hank’s apartment, encountering his partner’s girlfriend (Jennifer Gareis)– a holographic virtual construct. “Hank’s apartment was a real location,” Dave Drzewiecki stated, “and as a result, things were very cramped in there. We shot the plate of Hank and Adam live with encoding, then later matched the positions, played the move back, and shot the girl against greenscreen. Our greenscreen shoot was done in an old photo studio, and it was amazing to see what we could come up with when challenged– there was a cyc on the wall that wound up getting painted digital green and used as our background for the shoot.”

Creating a look for Hank’s special friend fell to VCE and Peter Kuran. “The holographic girlfriend was our entry onto the show,” Kuran stated. “Very early on, production had shot motion control tests of the girl– one with her wearing an evening gown, then another in her bra and panties. They had sent these out to see what various houses might do to make her into a hologram. I saw some similarity in her movements on these two takes, so I decided to try morphing her from the gown into the underwear. The director really liked our test, and we wound up doing the final sequence– a quite similar morph, with her again changing clothes.”

Kuran was intent on realizing hologram imagery that went beyond the standard double-exposed look dating back to Star Wars. “We processed the live-action greenscreen element to give the girl a textured, glassy appearance,” Kuran recalled. “The prismatic light-bending effect seen in the earlier holograms at the football game and at the police station is much more pronounced here, especially when you see her on top of Hank during a lovemaking scene. His face is seen twice, once normally and then again in a distorted form, filtered through her anatomy– which created a nice moment of comedy. Roger wanted to have fun with the character, and this helped get that across.”

Hank eventually falls prey to the eco-terrorist assassin, who, before expiring, reveals to Adam that his partner was in fact a clone. In a parking garage, Adam engages in a gunfight with Drucker’s cloned killers, shooting the fingers off Talia and blowing the foot off another. Working with multiple gelatin pieces, Bill Terezakis fashioned a hand appliance for the blowaway-fingers gag, while Rhythm & Hues provided digital finger and boot removal, as well as foosh gun fire. “We had to add a heat distortion for the garage gunfire,” Cheryl Budgett recalled, “plus a bit of smoke to tie in with the atmosphere used by main unit. We also wound up embellishing some of the on-set pyro with CG sparks, and borrowed practical pyro out of other scenes, as needed.”

Using the thumbprint from Talia’s severed digit, Adam gains entrance to the Replacement Technologies laboratory. Once there, he learns that Drucker is a fourth-generation clone, and that he himself had been cloned, together with Hank, because the company erroneously

believed they both had been killed on the mountaintop. To prevent any further copies being made of Drucker, Adam makes off with a memory disc containing all of the tycoon's cloning data, and Drucker retaliates by kidnapping Adam's wife and daughter. At this juncture, Adam meets up with his other self, and they agree to work together to rescue their family. Many of the dual-Schwarzenegger scenes were shot using motion control, but some of these still required additional finessing. "While the bluescreen and greenscreen elements of Arnold utilized motion control," Jerry Pooler noted, "a number of the background plates being combined with them needed to be tracked before we could make good comps. There was a lot of color-correction involved, also."



A foosh-gun blast- designed and executed by VCE - cuts through Morgan. Due to the volume of gunshots in the film, foosh-fire for some scenes was provided by Cinesite and Rhythm & Hues.

Though motion control was needed for many of the split-screen shots, Drzewiecki also lobbied for the employment of large-format cameras in the hope that some shots could be done locked-off- thus negating the need for motion control- with moves introduced later in post. "I find Vistavision to be an elegant format for the various ways it can be used," explained Drzewiecki. "To demonstrate possibilities for production, we shot a static setup test- with the camera very wide on the action- to create 'A' and 'B' sides of Arnold. We sent those to Cinesite; and a week later, Tom Smith brought a temp comp back up. He had introduced a move that panned from one side of this oversized film frame to the other; and seeing that was a real revelation for some of the production people, who embraced Vistavision from that point on."

Editorial enjoyed another advantage to using the oversize eight-perf format. "Whenever we shot motion control camera passes for the two Arnolds, the 'B'-side action had to be timed to mate exactly with the 'A'-side. Coordinating this is really tough; but with a locked-off Vista approach, there was no problem. We'd just slip the sync on the two sides to blend and match the actions flawlessly. This was really terrific for doing handoffs from one side of the split to the other and similarly tricky stuff."

A trade is arranged, with Adam's family to be exchanged for Drucker's disc, but this turns out to be a trap, with the Whispercraft- apparently piloted by Adam, but in fact being flown through the use of his remote control unit- destroyed by foosh fire. On location, high-speed cameras rolled as Michael Lantieri blew up one of the two practical Whispercraft mockups. In post, Cinesite added whirling CG blades that had to integrate credibly throughout a number of shots as the craft dropped from the sky. "We did rig removals, cleaned up the plates, and then did camera and object tracks before inserting the CG rotor blades," Lynn Basas noted. "The blades had to match with production's mockup as well as



A foosh-gun blast- designed and executed by VCE - cuts through Morgan. Due to the volume of gunshots in the film, foosh-fire for some scenes was provided by Cinesite and Rhythm & Hues.



On-screen cloning from generic blank forms- puppets created by Amalgamated Dynamics- to fully realized human entities entailed the use of intermediate-stage silicone heads which were photographed motion control and then morphed into a seamless transformation by Cinesite.

Rhythm & Hues' CG Whispercraft. They had proprietary animation and rendering systems, and since we didn't have an equivalent to that renderer, which included some motion-blur tools, we had to come up with our own approach." This took the form of a 2D solution, with digital artist Kenji Sweeney painting a motion-blurred blade and highlights, then mapping that onto a flat plane and rotating it.

While the 2D approach worked for the pre-blast, undamaged blades, Cinesite had to create geometry for the damaged versions. The original plan was to show one blade and part of another flying off, and a remaining rotor shard flapping around while the aircraft plummeted to earth. To create the proper dynamics, Cinesite ran a series of simulations. "We started by doing work on blade-spinning dynamics," Dave Altenau recalled, "then broke the 3D blades off while they were at speed, letting them fly away to get an idea of how gravity would affect the pieces. Typically, doing effects animation works with your intuitive sense of motion; but in this situation we were dealing with high-speed camera footage, so the slow-motion aspect caused us to readjust and reassess motion and speed."

Adam flies the remaining Whispercraft toward the Replacement Technologies building, which is seen in a lengthy point-of-view approach. The footage, captured via helicopter during a Vancouver overflight, was in fact of that city's public library; so some digital sleight-of-hand was necessary to give it a suitably dramatic presence. "In reality, the library was only four stories high, situated next to and in front of a taller, crescent-shaped building," Lynn Basas recalled. "The director wanted the main building taller and the other one de-emphasized, so we added two floors to the principal structure and chopped the other, which changed the focus of the shot."

"Our compositor, Tim Gibbons, had many problems to solve on this shot," added Tom Smith. "He had to not only stabilize the plate but also replace the background behind the now smaller building." To create textures for the library building set extensions, Cinesite wound up employing image-based modeling projection techniques. "That was new for us," Basas continued. "We used Maya tools to grab texture from a lower level of the real building, then copied that to the added pair of levels. We thought that a ton of additional modeling would be needed to render all the necessary detail, but most of the lighting was already in the part of the plate being copied, including shadows, so we only had to do a bit of plate modification to break up the look." Much more effort went into realizing the building's roof. "That was not the library's rooftop. Production had built a roof set elsewhere, so we had to copy all the textures from their set plate, duplicating that in CG and placing it within our extension."

Adam allows himself to be captured so that his double may infiltrate the building and free his wife and daughter. But once inside, Adam learns that he is not the original Adam, but the clone. In the ensuing chaos, Drucker is accidentally shot by Wiley, and the cloned Adam goes on a rampage, wreaking havoc in the facility. Pursued by Talia, the cloned pilot dives into the cloning tank while the mortally wounded Drucker is attempting to create another replica of himself. Talia shoots down into the tank, shattering one of the walls and causing the clone blanks within to spill out. ADI loosened the metal armatures on its forms for the scene, allowing the bodies to flop about as they poured from the tank onto the lab floor.

The ruptured tank and resulting pandemonium disrupts the cloning of Drucker, and his new incarnation emerges as something less than expected. The Cinesite morph of the character again utilized both ADI's clone blank and Bill Terezakis' in-between form. "The clone only develops to a certain point before the eyes open and it begins to move," Tom Smith said. "So our finish point had to look something like the makeup effect, which was a gelatinous gooey mass that looked like someone poured hot forty-weight oil all over it."

ADI designed a full-body makeup for the new Drucker. "The idea was that after being injected with DNA, a clone blank then begins to take on pigmentation," Alec Gillis explained. "In this case, since he gets yanked before imprinting happens, his skin is extra-translucent, and his hair is clear. We went with gelatin for the skin, then did the hair with fine two-pound monofilament fishing line."

ADI provided a range of gelatin pieces- along with a silicone headpiece- which Charles Porlier and his team applied on set. "There were gum plate pieces to make his teeth look shorter," Jeff Dawn said, "plus large, irregularly-shaped torso sections that could wrap around for use on fronts and backsides. We also had custom arm pieces that extended from the elbow down over the fingers. Rather than use an airbrush, we painted all the pieces by hand, mixing whites, yellows and browns to create a mottled look. ADI also made a transparent membrane-like material that could be applied over the skin, which added a lot to the look."

After working out all the application details using stand-ins, Dawn and Porlier brought in Tony Goldwyn. "We proceeded to shave him down from head to toe to avoid any problem with body hair," Dawn continued. "Tony never complained and was the complete pro, even though we put him through hell. It took between three and six hours to do the makeup, depending on whether we needed to do just his head or a full-body job. To make this a bit easier on him, I designed and built a custom application bench- I was a carpenter before I got into makeup- that was adjustable and allowed Tony to watch TV while lying down or sitting upright during the lengthy application. Usually we would have four artists working simultaneously: one on the hands, two more on body parts and another on his head. We'd use spray sealer to make sure everything held up under the stress of the day, and top him off with an application of ultraslime." While Goldwyn underwent the lengthy application and removal processes several times, his double logged roughly the same amount of time on the bench. "The double- who was a very close match with Tony in face, body and height- proved invaluable. Except for dialogue shots, just about everything- even head shots- could be done with him standing in."

In a murderous rage, the half-formed Drucker pursues the cloned Adam to the rooftop, where he also encounters the real Adam, who has returned to aid his doppelgänger after transporting wife and daughter to safety. Drucker tumbles onto an atrium and takes a multi-story fall when the glass breaks. The makeup department provided a dummy for the fall, preceded by a digital cracking-glass effect created at Cinesite.

The two Adams board their Whispercraft, taking flight just before the building explodes. To provide exterior views of the building's destruction, Fantasy II Film Effects built a large-scale miniature at their tank facility in Sun Valley. "We went sixth-scale for the model, which was supposed to represent a six-story building," said Fantasy II owner Gene Warren, Jr. "But since

the height of each floor at the actual building was eighteen feet, it was really like building an eleven-story model, winding up just over thirty feet tall. We also built a façade to represent the crescent-shaped building adjoining the main one.” Modelmaker Gary Rhodaback spearheaded the construction effort.

Detonation of the model took place in stages, with the first part of the blast– done with primacord– shattering every window. “We had safety glass in place for the windows,” Warren explained, “and we siliconed our custom window frames right onto the glass. We cut the frames in half or into even smaller pieces before adhering them, which gave us some variety in the look of the debris after the windows go. Then there was structural damage for the part of the building that breaks away after the main blasts– which we did with gasoline and powder charges to create huge fireballs. For that we used break-away concrete.”

Warren set up seven cameras to capture the explosion, which was shot high-speed at 96 frames per second. “The idea was to get enough coverage that editorial would have the option to allow the scene to play out at whatever length worked best,” related Warren. “There were three cameras down below the building, shooting upward from pillbox bunkers. Two others were mounted on a forklift and a cherry-picker to capture straight-on views. The last two were set up on a forty-foot scaffolding rig, shooting downward to get the explosion from the point of view of an escaping Whispercraft.”



Adam Gibson and his clone join forces to save ‘their’ wife and child, held captive at Replacement Technologies. Split-screen composites of the two Schwarzeneggers were produced by Cinesite.



For a helicopter approach to the Replacement Technologies building, Cinesite added two stories and a new rooftop to the Vancouver Public Library, which served as the live-action location, while shortening a taller building nearby.

While the original Adam returns to his family, the cloned Adam heads off to a life of seclusion in faraway Patagonia- a rather subdued end note for an Arnold Schwarzenegger action vehicle. But the film did manage to pay off the decade-old notion of Schwarzenegger sharing the screen, at length, alongside himself. An early James Cameron idea for Terminator 2 would have had the star essaying twin lead roles, as both good and evil cyborgs, but that concept was abandoned due to the perceived potential for viewer confusion. While Total Recall had briefly paired Schwarzenegger's character with a holographic duplicate, and Last Action Hero had featured a short sequence with the actor playing both himself and a fictional protagonist, it was not until The 6th Day that fans were at last rewarded with a true double-dose of the Austrian Oak.



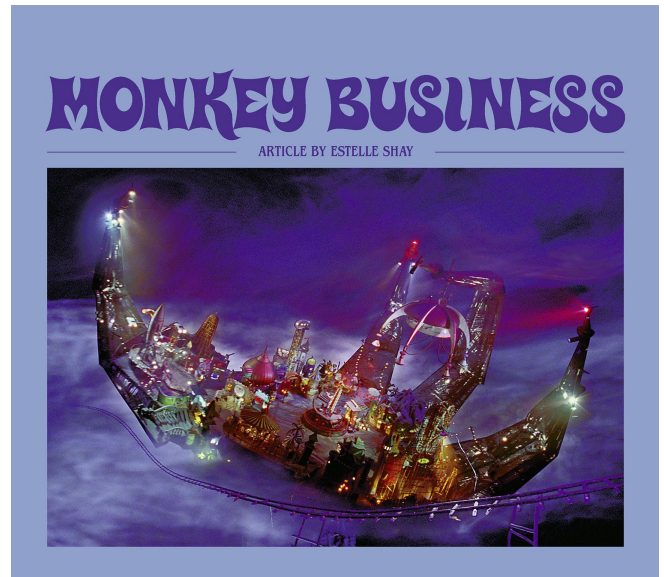
For a helicopter approach to the Replacement Technologies building, Cinesite added two stories and a new rooftop to the Vancouver Public Library, which served as the live-action location, while shortening a taller building nearby.

“Stylistically, the split-screen work with the two Arnold characters was, like most of the visual effects in The 6th Day, meant to be largely invisible,” Dave Drzewiecki concluded. “Roger Spottiswoode wanted to shoot those segments of the movie just like regular live-action, as if there were really two Arnolds on the set, and we did our best to support that vision. So there wasn’t need for much in the way of elaborate one-upmanship in terms of trying to top what’s been done on other shows with elaborate cross-screen handoffs and heavy-duty intersection between the characters. The split-screen stuff in Dead Ringers and Back to the Future II was spectacular; but those shots were designed to be a bit showy, and so that was not an approach that would integrate with Roger’s needs on this film. A more naturalistic approach is what was called for, and that is what we strove to achieve.”

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MONKEY BUSINESS

ARTICLE BY ESTELLE SHAY



In 1996, director and animator Henry Selick discovered a little-known comic book by Kaja Blackley called *Dark Town*. The striking graphics and quirky, bizarre story, about a puppeteer in a coma trapped in a limbo world between life and death, quickly caught the eye of The Man responsible for bringing *The Wildly* inventive worlds of *Nightmare Before Christmas* and *James and the Giant Peach* to the screen. Over the next few years, Selick would option the rights to the comic, teaming with writer Sam Hamm to craft a screenplay and partnering with producer Chris Columbus and his 1492 Productions. The end result is *Monkeybone*, an irreverent and darkly comic odyssey into the recesses of one man's mind. Fittingly, the Twentieth Century Fox release – while representing Selick's first foray into full-fledged live-action filmmaking– would still manage to tip its hat to the old-fashioned charms of stop-motion animation.

The movie revolves around cartoonist Stu Miley (Brendan Fraser)– creator of a raunchy comic-strip simian named *Monkeybone*– who is involved in a car crash and winds up in a coma. Though his body remains in the real world, his soul is transported to a carnival-like purgatory populated by a host of twilight demons– outcasts from mythology and pop culture who thrive on the nightmares of real people. Stranded there in the company of his own cartoon character, Stu has just twelve hours to find a way back to the land of the living before doctors pull the plug on his life-support system. His efforts, however, are subverted by the wily ape who ends up double-crossing him, returning in his place, and stealing his body and his life.

Though Selick had initially envisioned a much simpler film, with a live-action real world and an all-animated puppet world, the project's Evolution into more of a mainstream movie, and the need to hire a name actor, changed all that. Recognizing that audiences would want to see Brendan Fraser throughout the show, Selick changed the puppeteer protagonist to a cartoonist, and entertained the notion of filming the coma world as a live-action environment extended and enhanced through computer graphics. The problem of how to realize *Monkeybone* remained, however, and various strategies were considered before the filmmaker finally settled on stop-motion animation. "For *Monkeybone*, I had felt that some form of animation was the best approach from the get-go," commented Selick, "but unlike the films I've done in the past, this

was more of a studio show, and the studio wanted to explore every option.” Among the ideas tested was putting a small actor in an ape suit. Another involved combining the head, arms and torso of a live performer with rod-puppeted monkey legs– an approach that proved hilarious in execution but simply was not feasible, given the limitations of shooting. In the end, the story itself would dictate the best solution for the character. “At the beginning of the film, Stu is confronted with all these lucrative merchandising deals; but he’s an artist who’s not ready to sell out. So I had made it a very strong story point that Monkeybone, when he comes to life in Stu’s dream world, is this bad merchandising doll that our protagonist had earlier rejected. That story point really helped convince us that stop-motion was the way to go.” The decision, however, meant that an entire *modus operandi* would have to be devised to handle the two-hundred-plus shots in which the animated character was prominently featured, interacting closely with live actors in real environments.

For visual effects supervision, Selick turned to long-time associates Pete Kozachik and Peter Crosman. Both had teamed with the director in the past– Crosman on a series of animated MTV station IDs that had helped launch Selick’s career, and Kozachik on both *Nightmare* and *James*. “I felt it was wise to have both men,” Selick noted. “Peter Crosman was our macro expert. He understands the live-action world, knows everybody in the business, and they all love him. Pete Kozachik was our animation expert, in charge of shooting all the Monkeybone scenes, overseeing the animation and the model shoot, providing guidelines for what we needed on the live-action sets, getting the lighting to match and all those sorts of issues.”

In total, more than four hundred visual effects shots would be undertaken, many of them having to do with Monkeybone and the coma world, others involving a series of nightmare sequences– bizarre passages from the conscious to the unconscious that serve as darkly humorous flights of fancy adding to the story’s surreal aspects. Although the live-action for the film would be shot in Los Angeles, Selick and Kozachik opted to establish an in-house studio in San Francisco, where the animation for *Nightmare* and *James* had been done. “Setting up our own animation facility seemed like the smart thing to do,” Kozachik reflected. “There was this talent base in San Francisco that we could access– we knew everybody up there. Plus, Henry wanted to have his own facility if he reasonably could, rather than do the vendor thing. So we set up shop at the Custer Avenue Stages. From there, it was a matter of deciding what aspects of the work we wanted under our direct control, and what we could farm out.” Ultimately, it was decided that the animation and the model photography would be handled by Kozachik at the Custer facility. Everything else– including compositing of the stop-motion Monkeybone into the live-action, rig and wire removals, and assorted CG effects involving set extensions and character animation– would be farmed out to nearly a dozen outside vendors working under the guidance of Crosman.

Monkeybone opens with a cartoon feature of the simian star– compliments of Spaff Animation– which turns out to be a screening hosted by television network executives courting advertisers and toy merchandisers for their newest comedy show. Unaccustomed to his newfound celebrity status, the cartoon character’s creator, Stu Miley, quietly slips away with girlfriend Julie McElroy (Bridget Fonda), and is involved in an auto accident. As an ambulance races him to a hospital, Stu slips into a coma and a seemingly alternate reality in which he finds himself

sinking into a void through a Stu-shaped hole in the gurney- a practical gag rigged by special effects coordinator Paul Lombardi and his crew- and deposited into a rickety roller coaster dropping down toward what appears to be a giant spindly structure in the shape of a fist. As the roller coaster approaches the floating fist, the fingers of the hand unfold to reveal Downtown- a fading, rundown carnival town nestled in its palm.

Views of the hand seen from the roller coaster and at several other points in the movie were shot on an elaborate model- one of several built by M5 Industries, located across the street from the Custer stages- by director of miniature photography Eric Swenson. Working from plans provided by production designer Bill Boes, M5 principal and engineer Jamie Hyneman and production supervisor Jonathan Searles, together with a team of forty artisans, labored for the better part of four months to create the enormous mechanical structure. Spread open, the hand measured twenty feet from the tip of the little finger to the tip of the thumb, and, despite being fashioned out of lightweight aluminum and wood planking, weighed in at 3000 pounds. "It had thirty computer-controlled stepper motors," said Hyneman who, with Chip Flynn, devised the hand's complex mechanics. "I designed a special linkage that allowed us to have a single actuator on each finger operate a number of joints so that you could push on one actuator, and the whole thing would curl up, one finger after another. Then, so the buildings inside the hand wouldn't get crushed when the fist closes back up, the fingers were designed to pivot and recess into the structure- kind of like a big pop-up book."



In the Henry Selick fantasy, Monkeybone- with visual effects supervised by Pete Kozachik and Peter Crosman- comatose cartoonist Stu Miley (Brendan Fraser) finds himself roller-coastered to Downtown, an otherworld inhabited by an odd assortment of exceptionally strange creatures. Along for the ride is a come-to-life version of his cartoon character, Monkeybone, achieved via stop-motion animation.

Springing from the palm of the giant hand was the richly detailed Downtown miniature, complete with fully articulated Ferris wheel, merry-go-rounds and assorted other rides, and an array of architecturally distinct buildings and booths- all designed to match a full-scale set. Four thousand tiny lights provided practical illumination. "We had people working on this thing who will remember it fondly for the rest of their lives," observed Hyneman. "It was the epitome of a sweetheart model-building job. There was handpainted lettering on a fortuneteller's booth that would require a magnifying glass to read. There were tiny Chinese lanterns, and marquees with chaser lights. It was a tremendously complex, eerily beautiful thing."



Animator Justin Kohn makes a tail adjustment on Monkeybone.

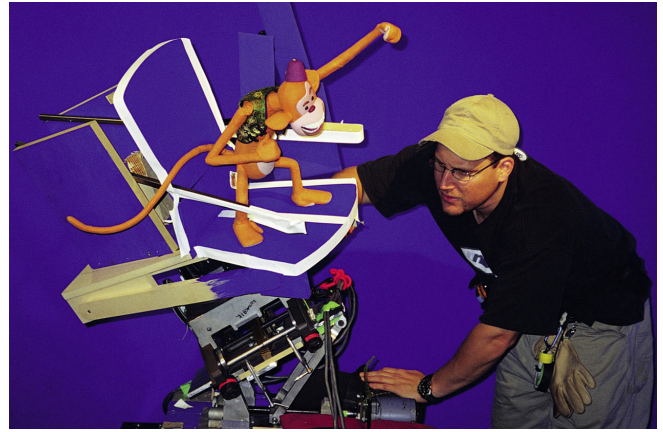
The entire main stage at Custer was given over to photographing the hand model and a seven-foot-tall detached wrist section, also built at M5. "There was supposed to be this long wrist that descends into the void," said Kozachik, "but since we could barely fit the hand model on the stage, let alone the wrist, the wrist ended up being a scaled-down model that we shot separately." The big hand model was mounted on a massive steel pivot so that it could be lifted and turned on its side to achieve overhead views of the hand without having to suspend the camera above the set. Both it and the wrist were shot motion control in multiple passes.

In postproduction, a CG cloud river encircling the wrist was one of about forty 2D and 3D digital shots executed by Centropolis Effects. "We went through quite a few concepts for the cloud river," recalled Centropolis visual effects producer Chris Del Conte, "since it existed only in Henry's imagination, and was- no pun intended- kind of pulled out of thin air. All we had to go on were initial drawings from the art department, which we used as a very loose launching point." Though 3D supervisor Rodney Iwashina had explored some volumetric rendering approaches using Maya and RenderMan, a quick-and-dirty 2D effect developed by 2D supervisor Abra Grupp would heavily influence the look of the cloud river. "Production needed an intro to the Downtown shot in the movie trailer," remarked Grupp, "so we looked around at everything we could get our hands on. It turned out that a liquid nitrogen element that they had given us for a completely different purpose worked very nicely as a basis for a 2D element." The loose, diaphanous interpretation of the cloud river resulting from Grupp's work would ultimately be integrated into the 3D work already in progress. "Henry saw it and really liked it, so we ended up actually using that to drive the concept." In addition to the cloud river, Centropolis created a CG roller coaster and track for POV shots from Stu's perspective as he descends into the void. The digital roller coaster matched an M5 model filmed on the stop-motion stages.

Coming to rest, the roller coaster deposits Stu in Downtown, a way station for coma patients like himself, run by an odd assortment of half-animal, half-human creatures. To realize the richly detailed, comically twisted Downtown environments, Selick turned to production designer Bill Boes, with whom he had worked before. "Bill contributed hugely to the artistic character of the movie," said Kozachik. "Henry has kind of a signature quirky, slightly dark, but still funny aesthetic- and Bill tapped right in-to that. So they were able to sync up perfectly and come up with all these amazing designs."

Chief among them was the Downtown carnival arcade, one of several full-scale sets built at Renmar Studios in Los Angeles. "That was the set Bill was born to design," remarked Kozachik, "kind of like Santa Cruz when it was still a funky town." Selick envisioned the setting as a skid-row Disneyland on Alcatraz. "I'm generally against things that are too slick and perfect," noted Selick. "I wanted the set to be crude-looking, dilapidated and rundown, with a lot of hand-made structures and details. I didn't want it to look like we'd gone to the prop shop and just assembled everything. Fortunately, Bill's natural style is to just get his glue gun and some wood, throw something together and daub paint on it- so it was a very good marriage."

For the weird array of characters populating Downtown, Boes, creature design consultant Ron Davis and a team of conceptual artists and storyboards brainstormed ideas and translated them into drawings and maquettes. The disparate styles of the artists- which ranged from cartoony and over-the-top to more hard-edged and stylized- co-existed comfortably within the coma world. One of Selick's directives for the Downtown denizens was that they be more grotesque than horrific- lumpy, misshapen and asymmetrical- a vision that once again reflected his singular design aesthetic. "Our blueprint for the characters was that they all had to be hybrids, inspired either by mythology or pop culture," recalled Davis, who personally devised about half of the twenty or so designs, while storyboard supervisor Mike Cachuela and illustrators Mike Mitchell and Lou Romano contributed others. "They were either ancient mythological characters that people no longer believe in, or they were retired advertising icons, fallen on hard times. The idea was to tweak them a bit, and make them a little more over-the-top, a little more fantastical, a little more cartoonish. For instance, we made Betty the Bovine-



All of the stop-motion was done on bluescreen stages, with a variety of rigs employed to integrate the animation with the live-action. Cameraman John Nolan prepares for a shot.



Animator Owen Klatte manipulates Monkeybone on a blue torso rig which was motion-controlled to duplicate the movements of Brendan Fraser in the plates.

who's an Elsie the Cow type figure- seem like an over-the-hill, overweight version of herself. The pig character, who's supposedly the corporate icon of a fast food franchise, looks demented and ill, like you'd never buy fast food from him. So they've not only fallen from favor, but they've sort of fallen from their fine form, as well."

One of the early concepts had all of the Downtown characters looking like papier-mâché carnival masks. "Only when they were experiencing their voyeuristic look at people's nightmares would they transform into seemingly flesh-and-blood characters," related Davis. "Coming from a theater background, I was really looking forward to that because you can do incredible things with papier-mâché heads. We were going to totally populate this world with them, then have only a handful transform into more detailed, lifelike versions." Though intriguing, the idea was eventually discarded due to concerns that it might not translate well to the screen. "Then we looked at doing all or a great many of them as stop-motion characters- but eventually we shifted more toward live-action, just as a practical matter." In the end, almost all of the characters were live-action performers in suits- the exceptions being Monkeybone and a pack of roadkill creatures, collectively referred to as 'street squash,' which were done with stop-motion animation. "With regard to the live-action characters, we looked for inspiration to classic circus and theatrical body transformation tricks, trying to find ways to tweak the designs to take advantage of what the performer could do physically to make the trick work."

The task of translating the designs into the live-action world fell to Steve Johnson's XFX and Keith Vanderlaan's Captive Audience Productions, with Johnson and his crew taking charge of the animatronics work, and Captive Audience concentrating principally on prosthetics. A range of techniques that included everything from delicate makeups to elaborately fabricated suits and mechanical heads manifested approximately twenty distinct characters, some prominently featured, others serving more as background figures.

For Johnson, the task proved to be a radical departure from the kind of creature work he was accustomed to handling. "In the beginning, I had a hard time wrapping my mind around Henry's design aesthetic," Johnson noted. "We couldn't approach this stuff at all like we normally would- realism was thrown out the window. In a lot of cases these characters were meant to look like mushy, kind of insane sculptures come to life; but it's a fine line to walk when you're trying to make something look purposefully cartoony, purposefully unfinished, and I was really afraid people wouldn't get it. In the context of the film, though, once I started seeing the sets and more of the elements of Bill Boes' production design, it all made sense."

Such a distinctive design aesthetic warranted an equally distinctive approach; and when it came to the heavy animatronics required for some of the characters, Johnson wasted no time pinning one down. "Since a lot of these characters were over-the-top in design and sculpture, I thought we should animate them the same way," Johnson continued, "so we took a fresh approach to the animatronic functions, bringing on Mike Scanlon- who's done quite a bit of work for the Hensons



both in London and L.A.- to key the engineering. Instead of going for subtle, realistic human movement, we said: 'Let's animate these characters like cel animation, and really go for broad, enormous moves.' We used leverage and paddles to animate the features, as opposed to sliding plates or standard cable mechanisms activated by a motor. That allowed us to get much broader cartoon expressions."

One of the most stylized of the creatures was Bull, the surly minotaur bartender at the Coma Bar, a local hangout where Stu and Monkeybone spend much of their time. Working from character designs of a human body topped off by an outrageous oversize head that resembled a Picasso painting brought into three dimensions, XFX artists built an animatronic headpiece that blended down to the mouth of the performer. In postproduction, Giant Killer Robots- one of the show's primary 3D vendors- would replace the remote-controlled head with a computer generated replica for scenes requiring more dynamic expression.

Another Coma Bar denizen is Jumbo, a four-armed Hindu elephant god who entertains patrons at the piano. Performing on stilts, the actor playing the eight-foot-tall character wore a full body suit and an animatronic elephant head, equipped with a mechanical trunk. Two performers in the suit, one sitting on the lap of the other, were used for wide shots of Jumbo playing the piano with all four hands.

Imaginatively employed suit performers were essential to other characters, as well. For the one-eyed Cyclops, XFX produced a giant animated head with minuscule body, sculpted to fit on the back of an actor who ambulated by bending over and walking backwards so that his legs would serve as the character's beefy arms. In another instance, a performer in a lightweight horse body- whose legs were articulated by rods attached to the actor's feet- enacted a cowboy centaur character dressed in fancy chaps and a ten-gallon hat. Thin black rods ran from the centaur's front legs to his hind legs; so as the performer walked, both sets of legs moved in concert.

Not all the creatures assigned to the XFX team would entail animatronics. One cleverly executed exception was Hypnos, the god of sleep, a key character in the Downtown world. A puppeting technique Selick had tested- and rejected- for Monkeybone realized the dwarf-like satyr, whose human head and foreshortened torso blended down into tiny goat legs. The performer, covered in greenscreen from mid-chest down, wore fake goat legs that dangled from his upper torso and attached at the knee with rods. The actor's movement as he walked about

Miniature unit gaffer Jason Predock checks the lighting on the upturned Downtown set fashioned by M5 Industries on the palm of a huge mechanical hand. The pivotal set was composited into a river of clouds by Centropolis Effects.



The denizens of Downtown- mythological has-beens and outdated advertising icons- were live-action characters produced via makeup and animatronics by XFX and Captive Audience.

on his knees keyed the movement of the puppet legs. His own legs were later painted out digitally.

At Captive Audience, effects supervisor Brian Sipe and his crew contributed a number of interesting additions to the bizarre panoply of creatures, most of them background characters. One comical standout was a three-headed devil, ingeniously realized by adding a mechanical third head alongside the real heads of performers Frit and Frat Fuller, an identical-twin dance team. The mechanical head not only precisely matched the look-alike actors- wearing heavy prosthetic makeups- but could be plugged into one of three neck positions in a special body rig worn by the twins and draped with a devil costume. "Frit and Frat would fill the other two positions, performing some of the head puppeteering from inside, while the rest was all controlled remotely," explained Captive Audience effects producer Keith Vanderlaan. "The head had tremendous facial expression, allowing it to follow and mimic what the twins were doing, so they could have kind of a three-way conversation. But we'd keep changing the position of the mechanical head so as not to give away the gag."

Another distinctive Captive Audience hybrid took the form of a wasp woman, seen flying around Hypnos' lair and lounging in his bed. For the flying shots, the effects crew- led by on-set effects supervisor Todd Tucker- positioned the actress atop a support, her body resting on a cushioned fiberglass rig that came up to her waist. Though a makeup appliance covered the front and back of her head, and a wasp pod concealed her trunk, the actress' legs were greenscreened and her upper body, from the base of her chin down to her waist, was exposed except for a sculpted bra and body paint. Three sets of wings with different speeds of movement were also created, with puppeteers controlling the wing movement. In postproduction, Digiscope replaced the practical wings and abdomen with CG versions to make the flying shots more realistic.

Soon after arriving in Downtown, Stu discovers that a stowaway in his backpack is none other than his own cartoon invention, Monkeybone, now come to life as a springy plush toy. Designs for the character would go through numerous iterations before Selick, working with Ron Davis and sculpture supervisor Damon Bard, finally hit upon the right look. "One idea that Henry came up with, and we really pushed, was Monkeybone as a stuffed animal- as opposed to some sort of strange character come to life," recalled Davis. "That crystallized into the idea of his being a merchandizing toy come to life and haunting Stu."

During the live-action shoot in Los Angeles, a variety of Monkeybone substitutes and props provided a frame of reference for the actors, as well as reference data for the animation work that would follow. "We had a bunch of green monkey bodies and monkey heads and arms," recalled Kozachik, who was on hand throughout first-unit filming. "A lot of it was very simple stuff. Sometimes we did things with fishing line or with a monkey on a stick carried by a green-suited performer- Bruce Lenoil- who was also Monkeybone's vocal stand-in on set. Then, in postproduction, the digital houses would have to paint him out in every frame. The bottom line in getting all that stuff, though, was that it had to be simple. First unit wasn't going to stand around waiting for an elaborate gag to be put together."

At the end of the live-action shoot, Selick and Kozachik headed north to San Francisco, where a crew of skilled and seasoned stop-motion specialists- nearly two-thirds of them alumni of

Selick's previous two movies- had been assembled at the Custer Avenue Stages. Included among them was a puppet fabrication team headed by character manager Bonita DeCarlo, nine key animators under animation supervisor Paul Berry and lead animator Anthony Scott, and five stop-motion camera teams. Nine eighteen-inch-tall Monkeybone hero puppets were fashioned- built full-size so that they could be shot alongside props from the first-unit shoot. Inside each of the fabric and foam puppet exteriors was a mechanical skeleton designed by Chris Rand and engineered by Merrick Cheney and Marc Ribaud. Several thousand replacement mouths and partial faces were also fashioned, designed to plug into the heads to effect realistic lip-sync and a full range of facial expressions.



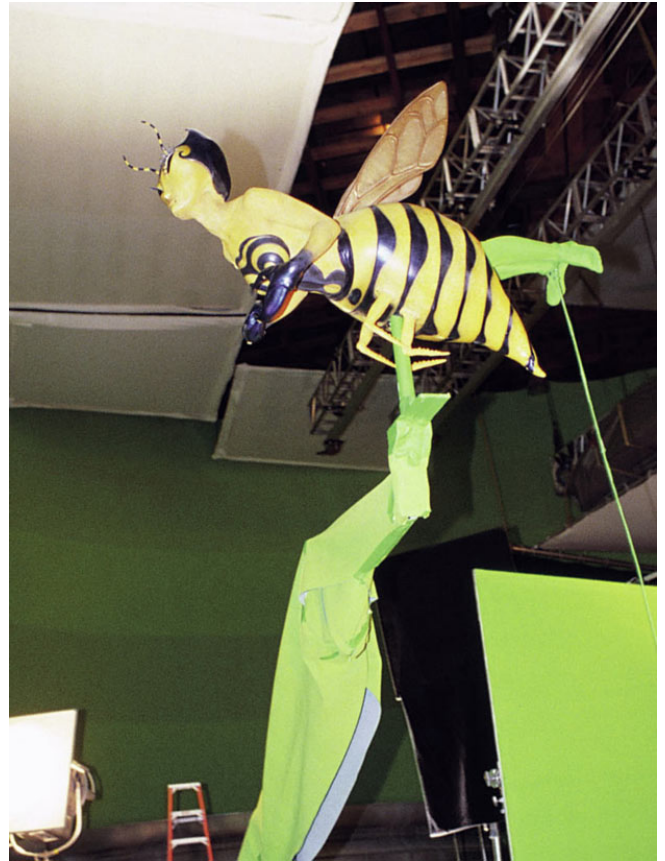
Hypnos- a satyr character with tiny goat legs- was created by XFX. Actor Giancarlo Esposito's real legs were covered with green to allow for their removal by Menace FX and Pacific Title Digital.

Though there were far fewer shots than on Selick's previous all-stop-motion shows, the task was still formidable given the need to re-create camera moves and motion-track the character with the live-action. Adding to the problem was the intense level of interaction between Monkeybone and his creator. "Frequently, Monkeybone would be on Stu's shoulder, or he would be jumping in and out of a backpack that Stu is wearing," explained stop-motion director of photography Jo Carson. "That was kind of his home, psychologically and physically. He'd pop out to make a nasty or funny remark, then go back into hiding, then come out again and jump onto Stu's head or get in his face." It was the kind of eye-popping interaction that had wowed Who Framed Roger Rabbit audiences back in 1988; only in this case, animators were dealing with a 3D puppet, rather than 2D cel animation.

"We figured that the tone for this sort of film was set by Roger Rabbit," remarked Kozachik, "and that there should be no holds barred with the animation. We didn't want to have to cut to the effects shot or make it a locked-off tableau. Everything had to be integrated with the live-action. But making a stop-motion character stick to live actors reliably was no simple matter. We had to come up with a three-dimensional way to duplicate what rotoscope artists do when they're projecting down and tracing cartoon characters like Roger Rabbit. That meant giving our animators and camera people a composite that they could see in real time on video while they were animating, so they could line up their animation frame by frame."

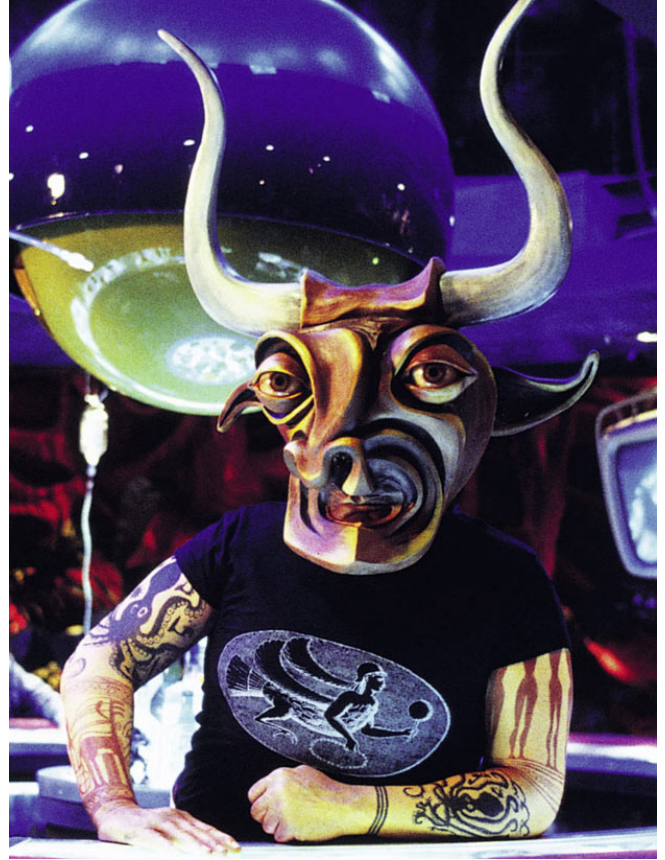
To accomplish precisely that, Kozachik had ten video animation work stations built for the animation stages, engineered to provide animators with rough video composites of the plate photography and stop-motion elements. "Those were built in-house by computer/video specialist Derek Gatlin," said Kozachik. "We also had optical engineer Mike Bolles modify eight Fries Mitchells to get a super-clean image going to a high-end, progressive-scan color video tap. Steve Rashke modified the video tap cameras to make time exposures, thus building up a brighter image just as time exposures do on film. This combination gave the best possible video image for our camera and animation crews to work with, and was crucial to our roto technique."

Syncing to the live-action was further aided by the creation of motion control rigs, built to anchor the puppets and match their moves to those of Brendan Fraser. The rigs, engineered by Nicholas Blake and Marc Ribaud, were essentially robotic replicas of Fraser's upper body, designed to duplicate and record whatever arm, head and torso movements the actor made in



Among the Captive Audience creations was a wasp woman flown on a crane rig.

the plate. "All of them were made from castings of Brendan," stated Carson, "painted blue so we could film them with the puppet Monkeybone against bluescreen to create a holdout matte. We would animate our puppet jumping around on these body parts, which could be motion controlled in every direction to duplicate Brendan's movements in the plates. Tim Taylor, our motion control specialist, did a great job of getting the motion control systems up and running, and keeping them happy and healthy."



Bull- the minotaur bartender with a face only Picasso could love- was created both as an animatronic makeup by XFX and a digital head replacement by Giant Killer Robots.

Having mapped out a basic visual vocabulary of walk cycles, runs and poses in advance, animators began working under the direction of Selick to pin down the puppet performance. "Because we had fewer shots to deal with, I could insist that we get it absolutely right," Selick related, "and all of the animators were at the peak of their game. Anthony Scott and Tim Hittle did the best stop-motion work of their lives. Trey Thomas was responsible for two of the best scenes in the show, including one where Monkeybone does this Marilyn Monroe routine in the Coma Bar. We had some British animators who were fantastic, too- Jeff Newitt, in particular, who was like a Zen master when it came to controlling the puppet."

Typically, the puppet's gross movements in the scenes would be blocked first, working out the animation and motion control camera moves in rough form. "That would give us something to talk about the next day," recalled Kozachik. "Then the performance would be refined. The goal was to get things figured out fast, so we could shoot the real thing as soon as possible." On any given day, some six or seven animation cameras would be shooting real shots with the hero puppets, while camera crews leapfrogged from one stage to another formulating additional setups in preparation for the next day's shoot. "Having a limited number of good puppets, we'd sometimes have to use stand-ins that weren't nearly as workable. But the camera guys could at least light with them."

A number of digital houses composited the stop-motion monkey elements into plate photography, providing the interactive touches and massaging needed to seamlessly marry the bluescreen puppet and live-action. Among those taking up the challenge were POP/R!OT, which handled about a hundred shots, and Digiscope, which did another seventy to eighty. Other contributors included Look Effects, Howard Granite Films and Pacific Title Digital. "I don't think there has ever been a show like this in terms of getting a puppet to defeat the stop-motion look and integrate with the choreography of live-action," observed POP visual effects supervisor David Sosalla, whose team often set the look for the Monkeybone composites done by the other houses. "What the director was looking for, and what everyone involved on the conceptual level wanted, was integration with a capital 'I.' That was really the key to making the puppet fall into the scene, rather than pop out of it." Key integration issues addressed on a shot-by-shot basis included such things as tracking fixes, shadow work, color and image quality, lighting and motion-blurring. "The motion-blur was quite an issue," commented POP digital compositor Patrick Phillips. "We really worked with Peter in getting the monkey to match according to what



Bull- the minotaur bartender with a face only Picasso could love- was created both as an animatronic makeup by XFX and a digital head replacement by Giant Killer Robots.

the other characters were doing. The motion blur is not all uniform. We approached it selectively from an aesthetic point of view, determining what looked best and what looked realistic and believable.”

Matching to the dark and lurid colors inherent in the show’s production design and dealing with the multicolored palette of the stop-motion character further added to the complexity of the composite work. “In the Coma Bar scenes, we would get something like three passes that represented three different exposures of the bluescreen monkey,” said Digiscope visual effects supervisor Brad Kuehn, “so we could key the colors off him properly. But to get his color scheme to match exactly, we had to key all of the different colors on him separately. So for one shot, even though it might have been just a two-element comp, we would have to pull something like six or seven different mattes.”

Principal scanning and recording for vendor shots was provided by Pacific Title Imaging, under the direction of imaging supervisor Tom Gorey. “Most of the companies worked with Cineon files, which were what we scanned to and what we find to be the most faithful representation of Kodak color space,” remarked Pacific Title visual effects producer Rodney Montague. “Kodak Cineon files are pretty much accepted at all the facilities around town. Since we ended up scanning a lot of the stop-motion monkey, it was very important that we maintain continuity across the board with the character.”

Stuck in Downtown, Stu discovers that he is soon to be disconnected from his life support when he attends a party and views a nightmare Julie is having in the real world. The sequence, one of several black-and-white nightmare scenes depicted in the film, begins innocently enough with Julie and Stu picnicking in a field of flowers. The hillside suddenly gives way to a darker image as people begin spiraling up through the ground to surround a now comatose Stu strapped in his hospital bed. Tipping champagne glasses and waving party balloons, the assemblage toasts the unconscious patient while a doctor, wielding giant shears, cheerfully snips an umbilical cord extending from Stu’s navel, causing him to deflate into a limp puddle of flesh.

For the hero shot– a dramatic push-in to Stu on the bed as the other characters spiral up– Peter Crosman shot the partygoers motion control on a motorized rotating platform, with the camera dolly in and dropping to impart the illusion of their rising. “First we did it with the whole cast– fourteen performers situated in different parts of the stage– to provide a template that we could use to pin down the camera movement and timing, and to make sure everyone hit their marks,” said Crosman. “Once we had that, we picked off each performer separately after greening the entire environment, so that every person could be his or her own keyable element. We literally ran the camera movement at real time, which meant it had to be a very robust camera, because it traveled quite far and quite fast. It took a very long time to shoot all fourteen people.”

Working closely with Crosman was a team from Graphic Nature, headed by Chris Cundy and Bryce Shields, which provided valuable on-set video assist for previsualizations and temp shots of final effects on nearly a dozen live-action sequences. “For this sequence,” said Cundy, “there was a bit of trial and error to make sure that everything timed exactly right in terms of when the platform rotated and when each of the performers rose out of the floor. Since the

filmmakers were playing fairly drastic perspective games with the motion control rig, they wanted to make sure everything was going to line up. So we would do the various passes- there were something like fourteen layers- and just gang them up, one upon the next."

The production footage was handed off to Centropolis Effects where it was composited in 2D and integrated with 3D digital elements, such as flowers transforming into smoke rings and trees into bubbles that gracefully float away. "Conceptually, the shot was very far out there," said Abra Grupp, "and we did just about everything you can imagine to it, using every piece of technology and just about every piece of software we had. To give the nightmare sequence an unreal quality, we found that we needed to stretch things farther than 2D could really take them."

The final shriveling effect was a practical stage gag executed by XFX using a body replica for Brendan Fraser. "We had this thermal gel plastic that could stretch as much as one thousand percent," Steve Johnson recalled, "and I suggested to Henry that we use it because I thought we could do something really fun with it. Brendan was wearing a hospital gown, so we had to do exposed legs, exposed arms and a head. For the head, we produced a soft understructure covered with this thermal gel skin. There were maybe twelve pick points attached to it, and as we pulled them and collapsed the understructure, his skin literally looked like it was sliding off. For the arms and legs, we did very thin castings of the thermal gel and kept them inflated with just enough air so they'd maintain their integrity and look solid. Then we sucked the air out of them as we stretched them to the ground, using a system of pulleys and fine wires. The whole thing was like a live-action cartoon."

With little time remaining before the real plug is pulled, Stu learns that the only way back to reality is through an exit pass issued by Death. Determined to steal one, he and Monkeybone sneak aboard a roller coaster headed to Thanatopolis, where Death resides. Flyby shots of the conveyance swooping down a twisted length of track featured a CG roller coaster created by Giant Killer Robots.

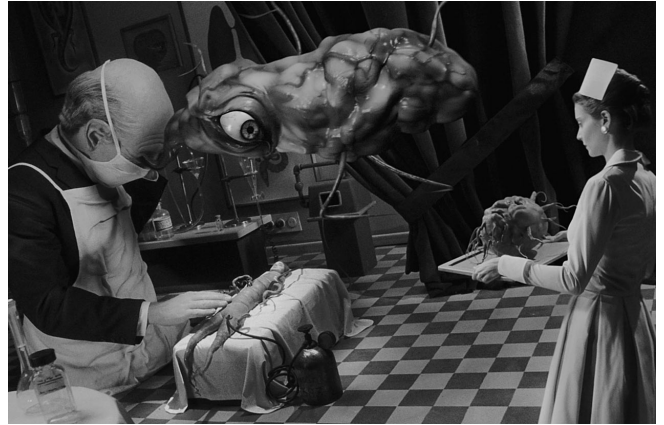
At the end of the line is Thanatopolis, depicted as an ornate railroad roundhouse where trains hauling the souls of the dead arrive and depart through an intricate network of tunnels. Since very little was built in the way of full-size set pieces, Eric Swenson captured most shots of the station with an elaborate, twenty-foot-wide miniature- built at M5, complete with moving trains, and photographed on the Custer stages. "The upper region of the station was like a giant greenhouse, with hundreds of little panes of weathered glass," stated Jamie Hyneman, "and the interior looked like a wrought-iron framework with ornamental filigree and thousands and thousands of rivets holding it together. It was an elegant



Miniature director of photography Eric Swenson prepares for a shot in Thanatopolis, the land of the dead, depicted as a giant Victorian roundhouse- constructed as a miniature by M5 Industries- to which trains deliver the souls of the departed.

piece- very gritty and dark, with backlighting that created a wonderful play of light filtering through the transparent panels."

A lengthy, 1200-frame opening shot establishing the environment begins with the camera tilting up to the domed roof, where Grim Reapers on flying bicycles- costumed performers shot on flying rigs against bluescreen- are seen spiraling down like moths. "The look of the Reapers- which is creepy, even though they're mostly clumsy stumblebums - was something that Bill Boes primarily came up with," noted Selick. "For the costumes, we wanted something nontraditional; so we made them white- kind of like a bad wedding gown- and with a hood shaped like a scythe." Continuing on its journey, the camera tilts down for a view of the roundhouse activity, then up again for a pullback through a window into a live set, where Death (Whoopi Goldberg) is busy processing souls. POP composited the opening shot and subsequent trainyard sequences, mixing and matching miniature and live-action sets, layering in atmospherics and bluescreen elements, integrating the stop-motion monkey and performing cleanup chores. "Pete Kozachik had supervised all the stage work," recalled David Sosalla, "and came to us with all the elements in hand and some rough Avid comps. We scanned in all the different layers and manipulated them into the solutions they were looking for."



In one of several black-and-white nightmares featured in the film, Stu imagines himself being surgically transformed into a vegetable. A flying eye, connected to a brainstem umbilical, was an animated CG creation by Giant Killer Robots.

Disguised as a Grim Reaper, Stu gains access to Death's office, snatches a golden exit pass and beats a hasty retreat, smashing through the plate glass window. As the general alarm is sounded, Death demonstrates displeasure by erupting into one of her frequent head-exploding tantrums- achieved in closeup with an exploding dummy head built by XFX and filmed against black. At POP, digital compositor Patrick Phillips assembled the shot and digitally enhanced it. "When the head exploded, the pieces of it flying off were barely visible," said Phillips, "so those had to be captured and intensified in the composite to look realistic. Then the wax head didn't line up completely with Whoopi's body, so it had to be warped and shaped a bit to match. There were other issues to overcome, as well, such as her hair flying. Whoopi had this long, almost dreadlocked hair; and that was not in the wax head plate, so I extracted a couple of frames of her hair and had it fly out of frame with the explosion." In a following shot, one of Death's minions retrieves a replacement head from a cabinet- another XFX replica with a screw-on base- and plops it on her shoulders. "We did a wacky morphing of this plastic head for that shot," said Sosalla, "and dissolved it over Whoopi's head."

Jumping aboard a train headed back to Downtown, Stu and Monkeybone are pursued by a menacing Super Reaper who swoops down on a winged motorcycle. The chase sequence would liberally mix live-action with miniatures and the ubiquitous stop-motion monkey. "It was pretty much no holds barred during the live-action shoot," said Kozachik, "since everyone presumed

that, for the stop-motion, we were going to track whatever camera motion had been done. So our camera crews and animators were dealing with some Steadicam shots, some not-so-Steadicam shots, things on booms- basically the whole scene felt like it was hand-held.” Shots of the attacking banshee were filmed against bluescreen with a performer in a suit on a full-scale version of the bike, while a quarter-scale puppet and bike served for wide shots. “Bonita DeCarlo’s crew made the puppet, and we put it on a mechanical bike that the M5 guys made. It was a sweet little motion control miniature. Henry wanted a lot of wind action on this guy, so we got a high-speed motion control rig and put together as fast a modelmover as we could to do pitch, yaw and roll on this thing. We brought in Kamela Portuges to puppeteer it, and we shot it as fast as the rig would permit- with fans blowing and lots of cuts.”

Just when it seems as though the interlopers are about to make good their escape, a nightmare mural- painted by Mark Beyer- descends like a curtain in front of the train, sending Stu flying into the canvas where he is absorbed into the scene. In the black-and-white world of the nightmare, Stu becomes the star of his own worst-case scenario- literally a vegetable with a human head attached to a carrot body. Hovering menacingly above him, a surgeon- with a giant head and a grotesque floating eye connected to a brainstem umbilical emerging from his eye socket- prepares to sever Stu’s real head and replace it with a tuber.

Working with Peter Crosman on the tuber nightmare was Giant Killer Robots, responsible for some twenty-five shots in the film. “Our challenge in this sequence was translating the feel of the painting into a sort of real-world setting,” commented GKR digital effects supervisor Peter Oberdorfer. “We had to convey the aesthetic of the painting, which had a very illustrated, stylized feel, and turn that into something more interactive, with live-action characters in it.”

On a forced-perspective set, Oberdorfer and technical director Michael Schmitt worked with Crosman to ensure that reference data was obtained as he filmed the surgeon- a performer in an oversized mechanical head built by XFX- interacting with an animatronic carrot body strapped to an operating table. Also delivered to the digital team were greenscreen elements of several foreground figures and another of Brendan Fraser’s real head. “We had to collage the whole thing together to create this kind of skewed perspective that matched the composition of the painting,” said Oberdorfer, “which involved people at different scales. Dan Rosen, who was with us on *What Dreams May Come*, took charge of the 2D compositing.”

For initial shots of the painting dissolving and becoming fluid as Stu is absorbed into it, Oberdorfer at first thought he might be able to extrapolate from the methodology utilized to similar effect in *What Dreams May Come*. “We thought we could use some of those same motion paint techniques,” recalled Oberdorfer, “but then realized that with this show we would have to get a lot more dimensionality and shading into the painting, and have it actually engulf the guy. We worked with different matting techniques and things like that to decide how the interaction would proceed.”

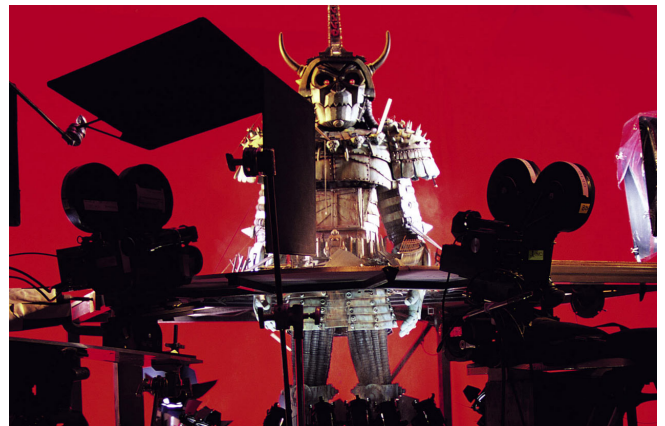
Especially prominent in the master shot that follows is the bizarre-looking digital eye that darts about the room on its umbilical. “That wasn’t something you could pull off any other way, because the eye had to be very fluid and organic- kind of moist and gooey and gross,” stated Oberdorfer. “It had to float through the air in a way that would have been impossible to do as a

puppet.” Digital artists also ended up replacing the animatronic carrot body used in the live-action shoot with a CG substitute, blending it with a greenscreen element of Brendan Fraser’s real head.

Moments before the surgeon’s ax finds its mark, Monkeybone saves Stu by reaching into the painting and yanking him out. Once they are safely back in Downtown, however, Monkeybone double-crosses his creator and steals the exit pass in a scheme to inhabit Stu’s body and mass-produce nightmares for Hypnos and his gang. An exit ride launches the simian, astronaut-style, through a portal opening in the skies above Downtown for the return trip to reality. Portal effects for the exit ride- also featured in an earlier sequence- were part of a thirty-six-shot assignment awarded to the two-man team of Curtis Augspurger and Buckley Collum of Menace FX. Tackling their first feature project, the partners worked from a painting by Bill Boes and Avid animatics that had the portal taking on the shape of a penny-head Abraham Lincoln whose jaw drops open to emit a beam of light- a Monty Pythonesque look that Selick loved. “Henry wanted a great emancipator for the portal between the nightmare world and the real world,” explained Augspurger, “so that’s how it came to be Abe Lincoln. We drew up this huge Lincoln head and tried a number of stylized looks on it- everything from a flat copper-penny look to this very anodized, oxidized look, all the way to a plaster kind of look. There was a continual Evolution because we had to make Lincoln completely recognizable even though he’s coming out of the sky, which isn’t something one would expect to see.” The sequence also featured sky effects in the form of a cloud-like, watery membrane that interacts with the Lincoln head. “We went through a couple of hundred different looks for the effects sky,” said Collum. “There were particle tests, paint tests, 3D displacements. Then Peter shot some cloud tank live-action photography up in San Francisco, and that became the basis for most of it.”

With the raunchy Monkeybone inhabiting his body, Stu awakens from his coma literally a changed man. Quickly embracing his creator’s fame, fortune and love-life, Monkeybone soon forgets all about his deal with Hypnos- until a nightmare jogs his memory. The nightmare sequence begins with ‘Stu-bone’ happily chasing skimpily clad lingerie models on a grassy golf course. Soon, though, he finds himself mired in a sandtrap as the landscape begins to shift into something darker and more sinister. Only his head is visible above ground when Hypnos approaches in a golf cart, strides to the sandtrap and prepares to clobber Stu-bone’s head as if it were a golf ball.

Menace FX performed leg-removal chores á la Forrest Gump for the actor playing Hypnos, and then created an abstract digital landscape for the metamorphosing environment. “Danny Speck was responsible for the animation of the golf course surfaces,” noted Augspurger. “We did a transition from the real golf course into these synthetic hills, which are seen growing up as the golf cart drives around them. They were very



At the end of the film, Death appears in the guise of a huge Japanese armored warrior, a suit created by M5 Industries and photographed against a red backing on the miniatures stage.

knobby, rounded hills with golf course flags on top of most of them, so it looked like a golf course gone awry. We added digital hills in some other shots, as well, because Henry liked them better than the live-action ones.” A hair renderer was used to create coarse, hay-like grass that covered the virtual slopes.

While Stu-bone cavorts in the land of the living, the real Stu manages to return to Thanatopolis and convince Death to send him back to the real world just long enough to say good-bye to Julie. The temporary body he is given, however, turns out to be a recently deceased athlete whose organs are about to be harvested by a team of surgeons. Much to the consternation of the surgeons, Organ-Donor-Stu (Chris Kattan) revives, wraps gaffers tape around his exposed insides and sets off in search of Monkeybone, dropping organs all along the way.

Makeup effects for Organ-Donor-Stu were provided by XFX. “For the surgery, we had a false operating table rigged with Chris Kattan’s body below it and a dummy body on top,” said Steve Johnson, “so the surgeons could really reach deep into the body cavity. Then, as he’s running around and his intestines or his pancreas or his liver are falling out, we did a fairly thick appliance for the actor’s chest and torso, and just jammed it full of internal organs that were rigged to pop out.”

Organ-Donor-Stu tracks Stu-bone to a fundraiser, where a wild showdown ensues and the two end up hanging from ropes attached to a giant runaway Monkeybone balloon being used for product placement at the event. The outdoor sequence was filmed in Exposition Park, at the Natural History Museum of Los Angeles, with a full-size, thirty-two-foot balloon, custom-made for the show, tethered to the top of the Exposition dome and flown from a series of cranes, which were later removed in post. Although Fraser and Kattan were filmed against greenscreen and composited into the background plate photography for most shots, Fraser and stunt doubles for both actors were also shot outdoors, suspended from a hydraulically operated cable rig engineered by Paul Lombardi and his crew.

A miniature balloon, filmed outdoors at Custer Avenue Stages, replaced the full-size one for several shots of its zooming about wildly, after a policeman punctures it with a bullet.

“Amazingly enough, we got it to look pretty much like a balloon that’s been punctured,” said Peter Crosman. “We worked with the stunt performers to create a crane gag where they were pulled two hundred feet up in the air, and we used that as the primary element. Then we used a six-foot balloon on a Condor crane and sort of engineered its path to complement that shot. So we were really taking a plate and an element from two outdoor shoots and marrying them together, with a lot of rotoscoping. I did a lot of rough compositing myself, just to work out the scenes so that I knew what I was going to shoot.” Final assembly was done by Pacific Title Digital, where a team led by visual effects supervisor Mark Freund handled a number of complex greenscreen compositing assignments for the show.

Tangled in the ropes of the rapidly deflating balloon, Stu and his nemesis— still struggling with each other— plunge to the earth with a sickening thud. But their fall continues on into the afterlife, through the skies of Downtown where the ground begins to tremble and open up as a sixty-foot-tall colossus— a mighty warrior clad in Japanese ceremonial armor— punches up through the ground to catch the plummeting figures in his outstretched hands. For the armored

colossus, a suit created by M5 and worn by diminutive performer Lorna Chul was captured as a high-speed miniature against a red screen, then composited into a master shot by Menace FX. "M5 also made some breakaway sections of the palm that were the same scale as the mechanical hand model of Downtown," said Pete Kozachik, "and we were going to run Lorna up through them with a pneumatic rig that they built. But I thought: 'God, she could break her neck.' So for three breakthrough cuts, we took her out of the suit and built a fairly sturdy steel framework to hold it in position, then just shot it up through those sections."

A door pops open in the chest of the colossus revealing Death inside a large machine room, working the controls of the mechanical giant, Wizard-of-Oz-style. A shot of Stu and Monkeybone in the hands of the colossus that booms in to reveal Death inside the doorway was composited by POP. "Most of the elements were filmed motion control, but the main one, introducing Whoopi, was just a simple dolly move, pushing in," explained POP digital compositor Michael Degtjarewsky. "Then we had miniature elements of the colossus, a live-action element of Brendan and a separate motion-controlled Monkeybone. The difficulty was stabilizing the shot and retracking it in match-move with the motion control. Because of the scale, it was difficult to find points to track that were occupying the same perspective plane that Whoopi was on, and we had to make sure we were consistent through the entire shot." Setting things right at last, Death claps the hands of the colossus together, sending Monkeybone back into the mind of his creator, and then propels Stu Miley back to the real world with a flick of its enormous mechanical finger.

With its madcap antics, comically oddball characters and noirish sensibilities, Monkeybone would prove the ideal vehicle for Henry Selick to test the waters of live-action filmmaking. The movie's true daring, though, was not its live-action, but its remarkable injection of stop-motion animation into the live-action world. The achievement was one that depended on the cooperation and resourcefulness of artisans across every level of production- in the animation studio, on the live-action stages and in the digital realm. "People don't think about how the monkey was done," commented Selick, "and, to me, that's a sign of success. Still, even though we did get better and better at doing it as we went along, it was an incredibly difficult challenge. With the right project and the right idea, I thought it could be a good marriage- and I believe it was- but I doubt it's something anybody else in the world would do."

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2001: A TIME CAPSULE

ARTICLE BY DON SHAY
JODY DUNCAN

2001: A Space Odyssey was four years in the making. This article on its production was twenty-four years in the making. Not twenty-four uninterrupted years, to be sure, but the germ of it evolved from a book on science fiction films that I started to research in the mid-seventies.

My first 2001 interview was with Douglas Trumbull, in November 1976. A few months later, in April 1977, I met with production designer Tony Masters. In early 1979 – after abandoning the book to start Cinefex – I returned to 2001 with the thought of doing a retrospective on the film that had so influenced a generation of effects artists. During that year, I managed to track down Wally Gentleman – the original effects supervisor – and almost all of the others whose memories form the heart of this retrospective. These sessions were handsomely augmented in 1980, when Jordan Fox, who contributed several articles to Cinefex in its early years and was planning a trip to England, graciously agreed to conduct an interview for me with makeup artist Stuart Freeborn.

So what happened to the retrospective?

I just never felt I had the full story. It was always a work in progress. There were key players I was unable to interview – including, of course, Stanley Kubrick who almost never gave interviews – and there was an unfortunate dearth of behind-the-scenes photographs. Still, it came up from time to time. We considered it in 1984, when the sequel, 2010, was released. Then there was the film's twentieth anniversary in 1988, its twenty-fifth anniversary in 1993, and its thirtieth anniversary in 1998. Each time we passed on it. But then came 2001. If we failed to do our retrospective in the film's namesake year, would we ever?

Suddenly, instead of seeing what we didn't have for the article, we saw what we did have – hours and hours of interviews, all of them unpublished and all of them (except for a 1984 session with cinematographer John Alcott) more than twenty years old. Not only did we have interviews with artists whose recollections were at least twenty years fresher than they are today, we had interviews with several who, sadly, were no longer with us. John Alcott died in 1986; Tony Masters died in 1990; Wally Gentleman died earlier this year. This retrospective is dedicated to them – and to Stanley Kubrick, who died in 1999.

Our history of 2001 is an oral history. It is not the complete story. Certain aspects of the work have been underrepresented, as have individuals whose contributions were far more significant than their presence here would imply. This is 2001 filtered through the memories of nine participants who saw the film and its making from nine discrete perspectives. These memories have been sealed in a time capsule for more than twenty years.

Open and enjoy.

Don Shay

Though scores of earlier motion pictures had endeavored to project man into space and speculate upon the consequences of his first contact with an extraterrestrial intelligence, 2001: A Space Odyssey was decidedly unique, both in concept and execution. In a cinematic genre where dramatic license was customarily stretched to preposterous proportions, 2001 remained staunchly rooted in the scientific principles that were so often disregarded by its predecessors. At the same time, it dared to be slow-paced, underplotted and obscure. Praised and damned with equal fervor, the film ultimately prevailed, on its own terms, as a convention-shattering experience of visual grandeur and artistic integrity.

2001 is divided into four distinct sections, beginning with a wordless, twenty-minute prologue in which a troop of ape-like human antecedents ekes out a meager existence in a barren desert wilderness. On the brink of starvation, and helpless in the face of savage predators, the hominids seem destined for extinction- until one morning they awaken to discover, standing upright in front of them, a towering black slab that arouses both terror and curiosity. Then, just as mysteriously, it is gone. But the monolith has left something with them- within them. Before long, once-passive troop members have learned to hunt and kill for food using heavy bones as cudgels- and more, have learned to employ these same tools as Lethal Weapons to drive another band of ape-men from a contested waterhole. Exhilarated by the bloody conflict, the victorious troop leader heaves his weapon high into the air.

In a stunning jump-cut spanning four million years, one instrument of warfare yields to another as the animal femur seen tumbling against the sky gives way to a nuclear bomb launching platform orbiting earth. It is now the late twentieth century. En route from the earth to the moon, with a stopover at a huge space station to change from one vehicle to another, is Dr. Heywood Floyd (William Sylvester), chairman of the U.S. Council of Astronautics. Under a shroud of secrecy, Floyd has been summoned to the moon to investigate a strange artifact-



The fusion of filmmaker Stanley Kubrick's visionary cinematic sensibilities with the literary finesse of science fiction writer Arthur C. Clarke resulted in the visually groundbreaking and wholly original 2001: A Space Odyssey. Begun in the mid-sixties- well before man's first venture beyond earth orbit- the movie took nearly four years to finish as Kubrick, ever the perfectionist, explored continually evolving story ideas and a vast range of innovative filmmaking techniques, agonizing over every frame of film. Mounting his production at MGM British Studios, outside London- far from the watchful eyes of Hollywood studio executives- Kubrick was joined by an international production team that included visual effects supervisors Wally Veevers, Douglas Trumbull, Con Pederson and Tom Howard. Kubrick and Clarke weigh in on one of the film's spaceship interior sets created by lead production designer Tony Masters.

another monolithic structure– that has been unearthed at a remote excavation site. When Floyd reaches out to touch the slab, as the ape-men had done, it emits a shrieking burst of radio energy– a cosmic signal to the stars and seeming confirmation that the monolith is of extraterrestrial origin.

The movie's third act takes place eighteen months later– in the year 2001– when a mission manned by commanders David Bowman (Keir Dullea) and Frank Poole (Gary Lockwood) is sent to Jupiter, identified as the terminus of the monolith's signal. En route to the planet aboard the massive Discovery spaceship, Bowman and Poole match wits with the malfunctioning HAL 9000 computer which has control over all of the ship's systems. The contest ends with the computer's deactivation, but not before Poole and three other members of the crew in hypersleep are murdered by the run-amuck machine. Only Bowman survives to reach Jupiter's proximity. The commander's approach of the planet, his apparent journey into another dimension and his ultimate arrival in a surreal alien world made to look like his own comprise the film's fourth and final act. A shot of the 'Starchild' – an evolved-human embryo seen floating in space toward the earth– closes the picture on an enigmatic note.

That narrative was the end-product of more than four years of ceaseless effort by two of the foremost representatives of their respective fields, filmmaker Stanley Kubrick and author Arthur C. Clarke. Kubrick, basking in the success of his recently released doomsday comedy, *Dr. Strangelove*, wrote Clarke at his home in Sri Lanka (then Ceylon) early in 1964, suggesting they collaborate on his next project. Convinced that statistical probabilities alone afforded sufficient evidence of intelligent life elsewhere in the universe, Kubrick had become intrigued with the idea of depicting on film the inevitable first encounter between man and alien being. Clarke, one of the most insightful and prophetic writers of science fiction, had explored that same notion in various contexts, and agreed to meet with the director to discuss the possibilities.

They met in New York in late April. Kubrick, who had already assimilated vast amounts of technical data on the subject, expressed his interest in producing a science fiction drama that would not only capture the awesome wonders of space exploration but also look beyond man's technological milestones to focus upon his basic relation to the universe. Kubrick claimed he could put anything on film that Clarke could put on paper, and his enthusiasm was infectious.

Even though, at that time, mankind had taken only its first tentative steps into space, and a manned lunar landing was still half a decade away, the two visionaries were cognizant of the fact that anything they might devise on the pioneering days of space exploration was likely to be overcome by imminent real-life events. Therefore, it was imperative that the technology depicted in the film be either authentic or logically extrapolated, that the visual effects be thoroughly convincing, and that the theme be sufficiently farsighted so as not to be outdated by an impending reality. In order to free themselves of any restrictions the medium of film might impose on their imaginations, Kubrick proposed that they collaborate initially on a novel and then proceed from there.

As a jumping-off point, Clarke suggested using a short story he had written back in 1948. Set in the early days of space exploration, "The Sentinel" detailed the discovery of a crystalline pyramid that had been erected on top of a remote lunar plateau millions of years before and

shielded through the ages by an invisible force field. Unable to crack the impenetrable barrier or comprehend the enigmatic artifact within, man ultimately resorts to the power of the atom and destroys both. Then, gradually convinced that the pyramid had been put on the moon as a cosmic intrusion alarm to signal when earth's progeny took its first leap towards the stars, mankind settles back in uneasy anticipation of a return visit from the alien emissaries who had placed it there.

After weeks of discussion, Kubrick and Clarke formalized an agreement to work together on the project. Kubrick bought the film rights to "The Sentinel" and five other Clarke stories, and the two set about conceiving what they originally intended as a sweeping documentary-style account of man's pioneering ventures to the moon and nearby planets that would climax with the unsettling and humbling discovery of an alien artifact. The rest of the year was spent refining the storyline. In the process, the sentinel concept became progressively more central, while material from Clarke's other stories fell by the wayside.

By Christmas, Clarke had finished most of the novel. On the strength of this manuscript alone, Kubrick managed to persuade Metro-Goldwyn-Mayer to underwrite his next motion picture. The first public announcement, in February 1965, was brief, but intriguing: Stanley Kubrick had joined forces with MGM to produce *Journey Beyond the Stars* from his and Arthur C. Clarke's soon-to-be-published novel involving exploration of the solar system and the discovery of an extraterrestrial intelligence. The big-budget production would be filmed in London beginning in August, with location shooting planned for Great Britain, Switzerland, Africa, Germany and the United States.

But *Journey Beyond the Stars* was far from ready to go before the cameras. Months later, Clarke was still laboring over his manuscript, radically altering whole sections of the novel on a day-to-day basis to comply with Kubrick's ever-changing cinematic vision. As Clarke wrote, rewrote, and then rewrote still again, Kubrick began assembling the core members of his production team. One was associate producer Victor Lyndon, who had served in like capacity on *Dr. Strangelove*. At Lyndon's suggestion, Kubrick hired production designer Tony Masters for the challenging task of creating a credible space-age environment projected some thirty years into the future.

Brainstorming sessions between Masters and Kubrick took place at the director's Polaris Productions offices in New York. "I spent about three months with Stanley," remarked Masters, "just talking about the script and trying to figure out how we were going to make this crazy picture. When you do a science fiction film, it's very difficult to discipline yourself to stay within reason. There are no limits and you can go berserk. Often the days would end up with both of us laughing too hard to work any more. As a stabilizing influence, we brought in a designer from NASA, Harry Lange, who knew rocketry and had worked with Werner Von Braun. He was our anchorman. From that moment on we would check with Harry and ask his advice on anything to do with space technology." In addition to possessing tremendous technical know-how, Lange was an accomplished draftsman and conceptual artist who, ultimately, wound up designing many of the spacecraft seen in the film, as well as the spacesuits and helmets. Though hired initially as a technical consultant, his broader contributions to the show would eventually earn him a production design credit. Joining the project at the same time was Frederick I. Ordway

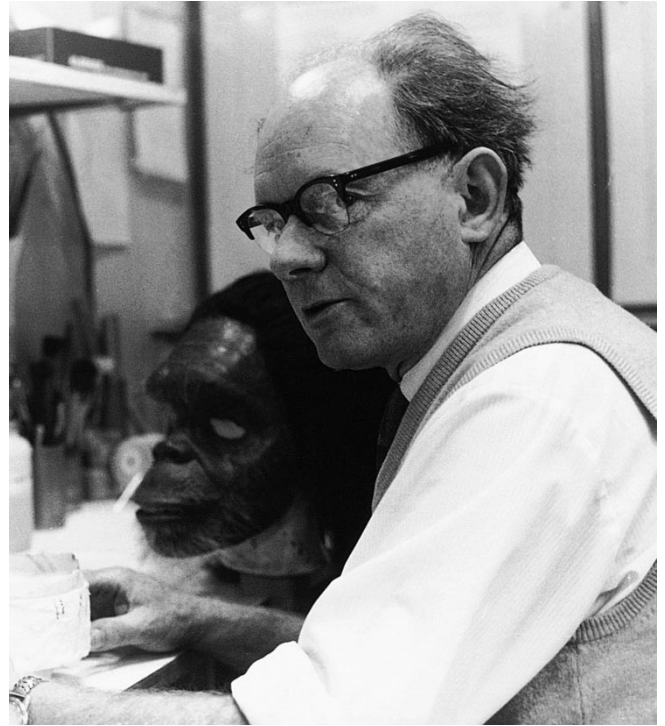
III, another NASA veteran who would play a vital scientific advisory role while also lobbying on behalf of the production for cooperation and support from leading aerospace corporations and organizations. Both men – partners in a flourishing space consultancy firm at the time– were recruited at the behest of Arthur Clarke.

Kubrick and Masters initiated the design process by gathering reference from whatever source was available. “Right from the beginning,” said Masters, “we went to scientific exhibitions to see the latest equipment from IBM and other companies. We also bought every book we could find on the subject of space and rocketry. We wound up with an enormous library of stuff- more than we ultimately needed since, at that time, we thought we were going to design another planet and see the extraterrestrials and how they lived. We went to quite a lot of trouble gathering the works of top science fiction illustrators, trying to work out what it might look like on another planet.”

Though the script was still in flux, Masters and Kubrick established design requirements for a vast orbiting space station and several short- and long-range spacecraft; and had, within a few months, settled upon many other basic designs.

Storyboarding, also, was well on its way, with hundreds of sketches lining the walls of Kubrick’s Manhattan apartment, where the night-owl director conducted much of his business.

Even as the script and production evolved, neither Kubrick nor Clarke was pleased with the working title selected for their project. Others– Universe, Tunnel to the Stars, Planetfall– were considered, but rejected. However, as the storyline shifted increasingly toward abstraction, the narrative’s epic scope and mythical elements intrigued both men. Clarke was consciously aware of its structural similarity to *Moby Dick* in the use of hard technology as a springboard for metaphysical speculation; and both he and Kubrick saw definite parallels to their space journey in the classic saga of *Odysseus*, with its attendant account of uncharted seas and the alien nature of distant



The Dawn of Man prologue featured ape-like human forebears created by makeup artist Stuart Freeborn.



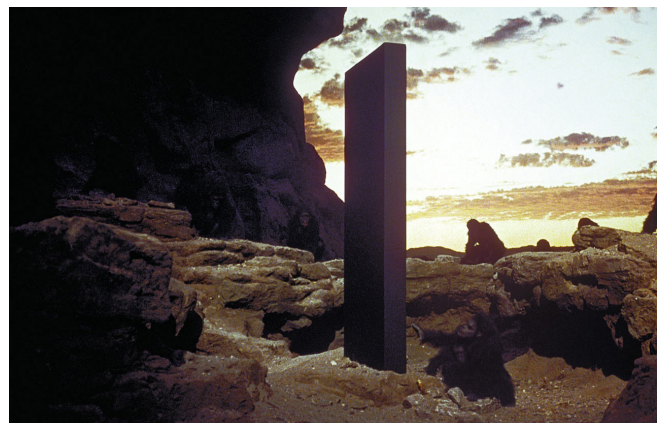
lands and peoples. So in April, nearly a year after their first meeting, Kubrick selected 2001: A Space Odyssey as the final title by which the film would be known.

During that year of preparation, Kubrick had done a commendably thorough job of viewing every science fiction movie or other cinematic work incorporating visual effects. Among the films that most impressed him was a 1960 short subject, *Universe*, which had made significant

breakthroughs in the creation of seemingly vast spatial relationships on an animation stand and in the combining of three-dimensional models with two-dimensional artwork. Kubrick contacted Wally Gentleman, director of special photographic effects for the National Film Board of Canada, who, along with associates Colin Low and Sidney Goldsmith, had devised the innovative effects for the film. "Kubrick had worn out a couple of prints of Universe trying to deduce how things were done," remarked Gentleman. "On the basis of what he saw, he wanted to get all three of us involved in Universe to do the effects for his big film production. He was looking for the very best quality that he could get; and the way he wanted to do it was to get everything on original negative, which is something we had largely accomplished on Universe. But, at that point, we were deeply engrossed in the planning of Labyrinth for Canada's Expo '67, and I was the only one willing to break free to join Kubrick in New York. Kubrick said he felt that six months ought to be enough for the job, so I decided to take a leave of absence from the Film Board. I was engaged as the director of special effects for the entire movie, but my main purpose at the outset was to act as Kubrick's general instructor in basic effects techniques. He had a commanding knowledge of still photography, but he was lacking precise knowledge of special effects operation. I must say that he was the most able student I've ever taught, because he could soak up information like a sponge."

A visit to the New York World's Fair also prompted Kubrick to track down the creative team behind a dome-projection Cine-rama 360 film called *To the Moon and Beyond* that was garnering widespread acclaim. The attraction had been produced by Graphic Films— a Los Angeles animation house specializing in nontheatrical pictures for aerospace clients such as NASA and the Jet Propulsion Lab. Kubrick invited company founder Lester Novros— a former Disney animator— and Universe director Con Pederson to New York to meet with him and review the script-in-progress and existing storyboards. All were enthusiastic at the prospect of working together, and Graphic Films promptly entered into a nonexclusive one-

The Douglas sight picture of *Flesh and the Devil* is what could be described as the epitome of the worst kind of male fantasy. The film is set in a remote jungle, the only facility is a small hut that houses a single female, and the only male is a white man who is the only one who can speak. The film is a masterpiece of the genre, and it is a shame that it is so poorly known. The film is a masterpiece of the genre, and it is a shame that it is so poorly known. The film is a masterpiece of the genre, and it is a shame that it is so poorly known.



Insurmountable logistical problems quelled early plans to shoot the *Dawn of Man* sequence in Africa. Intent upon featuring its singularly beautiful vistas, however, Kubrick sent photographers to the continent's deserts to capture large-format stills, which were subsequently incorporated into stage settings via a

year contract to develop an assortment of space designs and additional storyboards for the film. Contributing significantly to the undertaking was a young artist named Douglas Trumbull. "Con Pederson and I- Con in particular- had been deeply involved in quite a few NASA projects at Graphic Films," said Trumbull, "so we really knew a lot about space hardware and how it worked. We had done a film called Space in Perspective, which projected futuristic things that could happen in space- like giant floating hydroponic gardens and guys in little one-man space capsules with mechanical arms. A lot of what we came up with for 2001 grew out of things that we had done previously." Though it was agreed that the conceptual work would proceed in Los Angeles, the expectation was that Graphic Films would remain on the show when it went into production, establishing a satellite effects operation to support the project on-site.

In mid-summer of 1965, the 2001 preproduction team- then about ten people- moved into the MGM British Studios in Borehamwood, fifteen miles north of London. Although the screenplay seemed hardly closer to completion than it had numerous revisions before, Kubrick was now committed to a December start date for principal photography, and activity within the unit escalated feverishly. At the forefront was the art department, which quickly staffed up to a team of forty. "Ernie Archer was my assistant from the beginning," remarked Tony Masters. "He did a lot of work for the film and he got on extremely well with Kubrick. Others were draftsmen, set decorators and guys who designed the props and hardware. We divided the whole team into various sections- one bunch of guys would be working on one set; another bunch of guys would be working on another; and then, if it had anything to do with spacecraft, Harry Lange would come along and put his stamp on it by adding the right kind of detailing. Harry put the authenticity into it. The strange thing was that we all worked together for so long that we began to design in the same way. Just like 'Georgian' or 'Victorian' is a period, we designed '2001' as a period. We designed a way to live, right down to the last knife and fork. If we had to design a door, we would do it in our style. I think one of the good things about the picture is that it does have a definite style all the way through. It's not like a lot of science fiction movies I've seen where people will get together in a hurry and design all sorts of way-out and outlandish things, all completely different."

All of the designers were given a free hand, and were warmly encouraged to challenge their imaginations in envisioning the movie's near-future environments. "Stanley didn't offer many suggestions," commented Masters, "but he knew what he liked when he saw it. We'd come up with three or four ideas; and he'd look at them, and say: 'Well, I rather like this,' or, 'I don't know about that.' So, we'd have another go at it. This would go on for two or three weeks until we finally came up with a design he liked. But being a perfectionist, Stanley would change or alter things, and want things improved. You had to be enormously patient; because if you were not, or if you couldn't take criticism, then forget it- you couldn't work for Kubrick. Even when the sets were finished, he would come up and examine every surface and every wall, and if he saw even the slightest blemish- 'Ah, we have to do that wall again.' Everything had to be done

revolutionary front projection system devised by Tom Howard. For a shot of warplanes reacting to the sudden appearance of a huge monolith, foreground set pieces- constructed by production designer Ernest Archer- were lined up to an African sky, front projected onto a large eminently controllable lighting setup that helped to marry the location still photography to the live-action set pieces.

to a hand-rubbed motorcar finish. If he spotted a nail head anywhere, that was impossible, because this was a story about the future, and there could be no imperfection. So we'd have to go back and redo it. But out of it all came something very good; and it was good for all of us, I think. You just wouldn't want to do it too often- it takes years off your life."

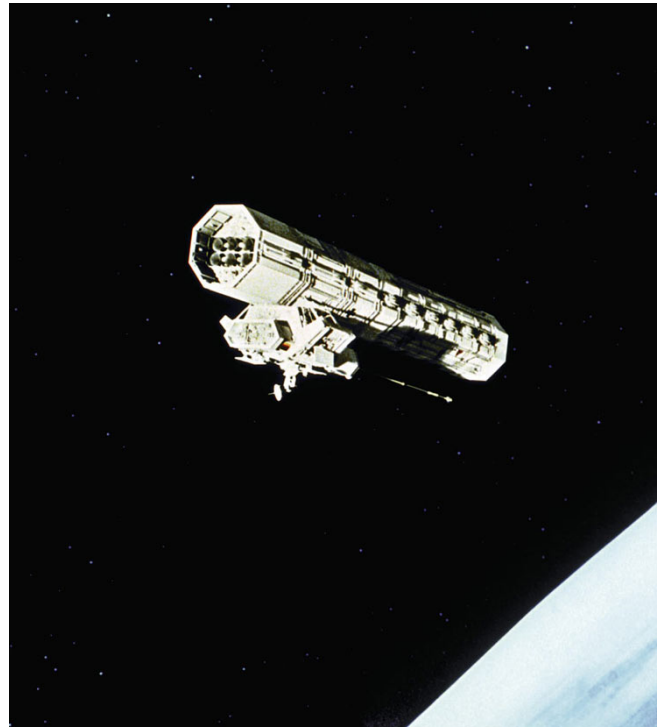
Craftsmen and technicians were hired in abundance as the production geared up for the December start. Joining the effects team were Wally Veevers, a Dr. Strangelove alumnus who had long headed the special effects department at nearby Shepperton Studios, and MGM department chief Tom Howard, a master at optical trickery who had earned Oscars for his work on Blithe Spirit and Tom Thumb. Both men would play major roles as the production progressed.

As senior supervisor at the time, Wally Gentleman had spent his initial weeks in England striving to lay a solid foundation for the overall effects operation. "From commencement," said Gentleman, "I tried to impress upon Kubrick the necessity of having our special effects equipment set up in a sterile environment. The optical and process work on the animation stand had to be in a sterile environment- otherwise, every speck of dirt would become an unwanted star. The models themselves could stand a dirtier stage, but even there it was important to keep everything as clean as possible. If you have dust floating in the air when you're flooding a set with very powerful lights, you end up with what looks like bright stars drifting all over the place. But Kubrick couldn't seem to understand why dirt would play such an enormous factor in assembling these images. His original plan was to set up the effects work in a giant aircraft hangar, because he realized that the shooting would be very protracted and he didn't want to deal with the expense of having to shoot all of that time in the studio. So the idea was that we'd design the methodology for the effects, then go and lose ourselves in an aircraft hangar for a couple of years after principal photography. Fortunately for us, MGM was in a recession and was closing down the studio laboratory- a good, clean, air-conditioned space. I said to Stanley: 'Look, this facility is being ripped out. Let's move in there.' I think he got a special concession on price, and we ended up doing everything in that old defunct lab."

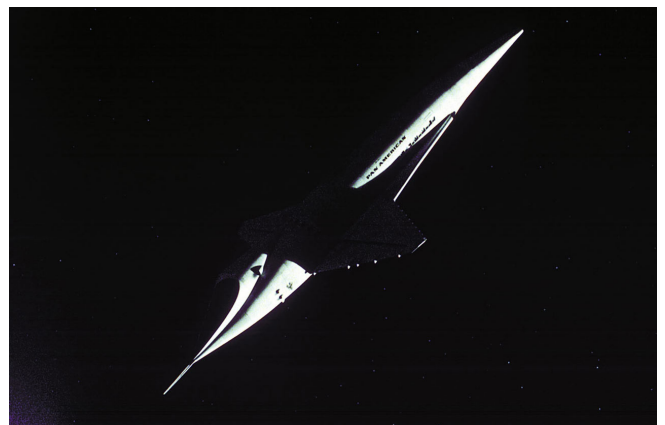
Once established, Gentleman began overseeing tests of various Kubrick ideas- ideas which ranged from the sublime to the ridiculous. "There were lots of tests," observed Gentleman. "In fact, I got very frustrated with Kubrick because he kept asking me to do experimentations that I knew wouldn't work. He would say: 'Well, you know it doesn't work because you've tried it. But I'd like to see for myself.'

"One of his ideas came out of our early discussions regarding propulsion for deep-space travel. At about that time, NASA had come up with the notion of detonating atom bombs as a means of propelling a ship. As soon as your speed dropped, you would pop out another atom bomb and the explosion would drive it forward again. One day, Kubrick said to me: 'Wally, what do you think of this? NASA says the technique they would use for deep-space travel is to have the ship farting its way across the universe.' Well, obviously, that was ludicrous. The next idea was the ion engine- propelling the ship along by emitting a stream of electrons. That was fine, but you had to see something. Kubrick thought we could suggest a big radiant engine pushing out energy by putting a hot-wire fan on the back of the ship. And I do mean hot- pulsing something like four hundred amps through thin wires to make the wires glow. Not only was it dangerous, it was ridiculous- because the moment you try to put light on a hot wire, it becomes gray. But Kubrick wanted to be shown, so we had to show him."

Another dubious idea sprang from Kubrick's determination to replicate the single-source, high-key look of space photography by illuminating the models with a brilliant strobe light. "We knew that by using a point source at a long distance we'd get very hard black shadows," continued Gentleman, "which is what we wanted. Kubrick thought that the way to do it was with a photographer's high-intensity strobe light; so we conducted a test with a six-foot model of the Discovery, which we



Four million years of human Evolution are compressed into a split second as the film jump-cuts from an animal- bone cudgel tossed into the air to a nuclear weapons platform orbiting the earth. The film featured dozens of scientifically sound ships and related space habitats. Models were constructed and photographed under the supervision of Wally Veevers. Basic ship shapes were built by an outside vendor, then thoroughly kit-bashed by the studio effects team to add an adequate level of detailing.



Summoned to the moon to investigate the discovery of a prehistoric monolithic structure, Dr. Heywood Floyd, chairman of the U.S. Council of Astronautics, travels aboard the Orion shuttle spacecraft - a three-foot model- which rotates in sync with a huge space station as it prepares to dock for an in-transit stopover. Ship maneuvers were achieved by wholly mechanical means-

mounted on something like the edge of a lathe bed, with a screw thread so we could inch it along incrementally on a worm gear. We would open the shutter of the camera in total darkness, flash the strobe to get our exposure, then close the shutter and advance to the next frame. Then we'd move the model a bit and repeat the whole operation. The problem was that we'd be sitting there in total darkness; and when this great sunlight flash came on, no matter what we did to block it out, it would burn the red of our eyelids right into our eyes. A half day of that and we were practically blind.

without the benefit of computerized motion control which would revolutionize visual effects a decade later.
A view from the Orion cockpit as the ship approaches the space station docking bay. Eight feet in diameter, the wheel-shaped space station model was dressed with hundreds of tiny lightbulbs to represent interior illumination.

"To be fair, some of Kubrick's ideas were very good. One was his suggestion of using a video monitor to help in constructing the models. In the past, I had always built my models through a dummy camera- we'd set up the camera the way we wanted to shoot, and then we'd build the model by checking it through the camera. Kubrick's idea was to set up a television camera, and then have a monitor right in front of us so we could fashion our models by looking into the TV tube. An excellent idea."

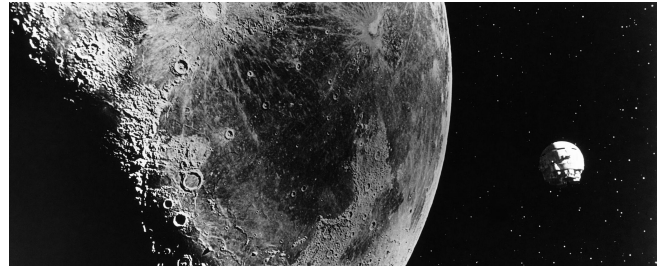
While Gentleman was setting up shop at MGM Borehamwood, Doug Trumbull and Con Pederson continued to submit illustrations- primarily space environments- from their home base at Graphic Films in Los Angeles. "I remember doing some drawings of the moon base for Stanley," related Trumbull, "conceptualizations of what the base might be like from an exterior and interior point of view. I also did some drawings to show what the landing pad might be like. We explored all kinds of ideas, like an indoor low-gravity gymnasium. We also did drawings for some of the orbiting probes and a couple of the spaceships. None of it wound up in the movie."

With computer modems and fax machines still in the realm of science fiction, the conceptual sketches had to be reduced to airmail-size proportions, then sent to England. Kubrick soon found the long-distance relationship untenable. "Stanley didn't want to go any further with the Graphic Films contract," said Trumbull, "but he was certainly very interested in our talents. That was no problem for me, because by then I'd been laid off at Graphic Films; so, I was the first one to arrive in England. Con was on contract to Graphic Films, and had a bit of difficulty getting out of it; but finally he did, and he came over a couple of months later.

"I was twenty-three at the time and didn't know anything really- just a little bit about animation and background painting. I didn't even understand photography very well. Before I left for England, I bought a Pentax camera; and when I got there, I started fooling around with a little black-and-white darkroom at home, just learning the fundamentals. But I was really just an illustrator- and by the time I started on the picture, things had already been pretty heavily storyboarded, sets had been designed, certain sets were already under construction, and I thought, 'Well, I've gotten here too late.'"

Not so. Two years later he would still be on the show; and by the time it wrapped, the scope of this erstwhile novice's contributions would be reflected in his earning the credit- together with Wally Veevers, Con Pederson and Tom Howard- of special photographic effects supervisor. Immediately upon his arrival in England, Trumbull immersed himself in the production of

graphic displays depicting various ship functions on the Discovery spacecraft. Dozens of monitors and screens would be incorporated into the shipboard environment to present these visual graphics, which were rear-projected from points of concealment within the sets. "We needed something like twenty thousand feet of continuous read-out animation for the various monitors," commented Trumbull. "I began by doing what I had been taught at Graphic Films, which was to organize everything and do it one frame at a time, with scene folders for each shot. We were trying to set it all up this way and then subcontract the actual animation photography to an animation service near the studio; but as we got into it, we realized that, projecting out the rate of footage we were getting in a week, it would have taken us several years just to do the readouts for HAL."



Floyd transfers to the Aries lunar transport for the final leg of his journey. Due to the volume of shots and the complexities of shooting models on stage, the effects team frequently resorted to decidedly low-tech solutions for achieving views of ships in space. Shots having little or no perspective shift were generally accomplished two-dimensionally on an animation stand using high-quality photographic cutouts of the models mounted on glass panels. The moon- a large glass-plate telescope photo obtained from the Lick Observatory- was also shot on the animation stand in a separate exposure from the starfield.



The Aries prepares to set down on the moon. The model- whose basic three-foot-diameter form was built by the outside vendor- was equipped by the effects team with motorized retractable landing legs and compressed air in the exhaust nozzles.

Clearly, a new methodology was needed. To this end, the production hired Bruce Logan, a cameraman with the outside animation service, to help set up an in-house animation unit. "We hated sending things to other animation houses," said Logan, "because it took such a long time and we had to spell everything out on dope sheets so the cameraman would know what to do. We knew we could do it much faster ourselves- but we didn't have an actual animation stand at the time. One was on order from Oxberry, but it hadn't arrived yet. So we had some of the studio grips jury-rig an animation stand for us using two-inch pipes and clamps. It was just a metal frame with a large sheet of glass on it and some lights underneath." Unlike a true animation camera, which is mounted on vertical tracks so it can be moved toward and away from the artwork being photographed, the makeshift 2001 camera- an old Mitchell cannibalized from an optical printer- was fixed in place and used a zoom lens to effect its moves. "The kindest thing you could say about this rig was that it was primitive- but we generated a tremendous amount of material on it. A lot of the readouts were generic- nothing very carefully thought out. There just needed to be something always moving on the viewscreens. Doug and I would strip up graphs and such, and then start blinking on lettering and numbers."

Thousands of pages of graphs and charts xeroxed from magazines such as Scientific American provided additional readout material. "We had all these things blown up into giant piles of high-contrast negative transparencies," said Trumbull. "We also devised a fake language- HAL's language of numbers and letters- with strange little acronyms and three-letter words, which we typed up on an IBM typewriter. We'd sit there at the animation stand cranking out enormous volumes of footage, one frame at a time. We'd shove this stuff under the stand and line it up by hand, put a red gel over it, shoot a few frames, then move it



An Aries flight attendant- wearing velcro-soled shoes to keep her floor-bound in the weightless environment- carries Floyd's inflight meal from the ship's galley. When the actress stepped onto the cylindrical passageway at the rear, the galley set began to rotate slowly, creating the illusion of her zero-gravity walk up the wall and ceiling. The camera was locked into place on the set to preserve its original orientation.



around and burn in something else or change the numbers. It was all just tape and paper and colored gels.”

Some of the more complex readouts would require multiple passes. To accomplish repeatable movement- long before the advent of computerized motion control- Trumbull improvised mechanical rigs that synced the camera functions up with the moving glass tabletop on which the animation artwork was set. “Doug was always coming up with these little rigs,” said Logan. “He would buy a lot of stuff from Edmunds Scientific and other companies, little engineering kits that had all sorts of gears and cams and things, and he would come up with these neat devices that drove directly off the camera so they would be in sync with the film as it was running through. The camera could shoot, say, a hundred frames of film as the table was going through a certain movement via a series of drives and cams; then we could rewind the film and photograph the artwork again at a different focal length. The table would go through exactly the same movement, but because of the focal-length change, it would tend to be in a different perspective.”

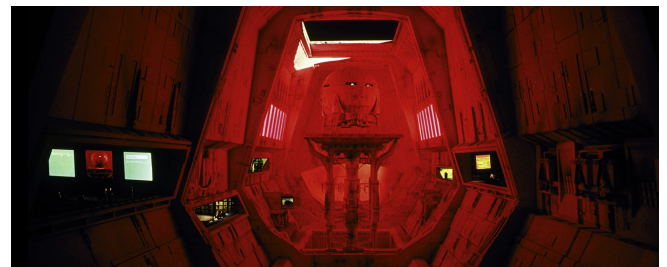
“We took plexiglas and put it over a sheet of glass with lights behind it,” elaborated Trumbull. “We put marbles between the two sheets so the plexiglas could just float around, like on ball bearings. We connected cam gears to the sides of the plexiglas so it would go through strange oscillations, and then connected the gears to the animation camera motor, and from the motor to the zoom lens on the camera. We could then put our negative transparencies on the plexiglas and do multiple exposures with totally coordinated pan, tilt, rotation and zoom.”

Scenes in which the displays took center stage would call for more complex setups. “There were readouts relating to specific story points that were featured quite prominently,” said Logan, “and we used a variety of techniques to achieve them. For example, there was a sequence where the astronauts bring in the AE-35 unit- which is the antenna HAL reports as malfunctioning- and put it on a test bench to study it. We needed specific readouts for that. To do what looked like a computer representation of the unit, we built a physical model of the AE-35 out of white wire. We put that on a little gimbal and photographed it

An Aries flight attendant- wearing velcro-soled shoes to keep her floor-bound in the weightless environment- carries Floyd’s inflight meal from the ship’s galley. When the actress stepped onto the cylindrical passageway at the rear, the galley set began to rotate slowly, creating the illusion of her zero-gravity walk up the wall and ceiling. The camera was locked into place on the set to preserve its original orientation.



Astronauts overlook the sprawling Clavius moon base as the Aries comes in for its landing. Live performers were photographed on a small lunar set piece against a front projection screen onto which was projected a large-format transparency of the moon base miniature. The earth and stars- and the Aries- were shot on the animation stand and composited with the foreground and front-projected imagery in-camera.



After landing on a hydraulic platform at the lunar base, the Aries is lowered into a subsurface airlock. Kubrick initially rejected the idea, by Tony Masters, to create the airlock set as a large-scale miniature. Convinced it was the best solution, however, Masters built the twelve-foot-long set on

with a Nikon against a black background, frame by frame, tumbling in different directions. From that we made high-contrast negatives, retouching them a bit if the line rendition was not quite

his own time- and Kubrick loved it. The model was enlivened with live-action matted into its control room windows.

perfect. We stripped those up on animation pegs and shot them through colored gels. It was like three-dimensional wire-frame animation- only with real wire."

Another shot in the sequence featured an x-ray scan of the unit. "To do that," observed Trumbull, "we took the unit, which was a prop for the movie, and mounted it on a circular piece of plexiglas with a ring around the edge so that we could number each position and rotate it. Then we took it down to an x-ray shop in London and had it x-rayed from three hundred different positions so we could have animated x-rays of the unit."

Docking sequences also required action-specific readouts. "We had a rectangular shape that represented the docking area in the space station, for example," explained Trumbull, "and we were rotating, panning and tilting, and tracking in on it simultaneously. We could photograph that, say, in eight exposures- the only difference between each being that we would adjust the zoom lens to a different focal length each time- and it would make up a three-dimensional rotating rectangle that you could track in on. Everybody thought we'd done it all with computers, but what we used were just simple little mechanical rigs that we built." Though photographed in 35mm, most of the readout material was reduced to 16mm since there was rarely room to conceal anything larger than a 16mm projector in the set.

On December 29, 1965, before an army of bustling film technicians, six American astronauts set eyes upon the most mind-boggling discovery of Modern Times, and 2001: A Space Odyssey officially got underway. The reveal of the alien sentinel on the surface of the moon called for an excavation site more than a hundred feet long, fifty feet wide and thirty feet deep, buttressed by steel retainers. Too big for MGM Borehamwood to accommodate, the crucial set underwent construction at nearby Shepperton Studios, on what was then the largest stage in England. With customary attention to detail, Kubrick had consulted his battery of technical advisors as to a likely color and texture for the lunar surface. Many different substances were tested before he settled upon ground coke, tons of which were subsequently procured from a local gas manufacturer, then washed, dried and dyed gray before being applied to the excavation set. Since the Shepperton stage was committed to another production in early January, Kubrick had only one week to complete the vital shooting once the set was completed.

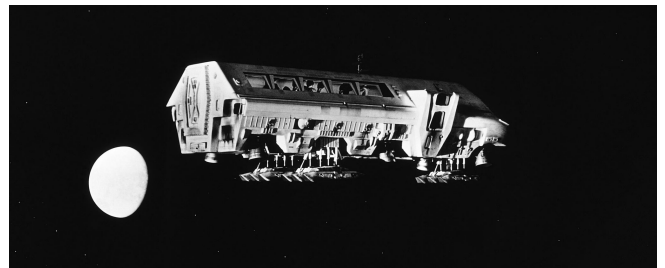
For the alien artifact- which would also figure prominently in the opening 'Dawn of Man' sequence- Kubrick and his design team had at first decided upon a tetrahedron, a pyramidal shape comprised of four triangular surfaces. "The tetrahedron had the least number of faces with the most surface area," said Tony Masters. "Why that should have been the right way to go, I really don't know, but it seemed a nice shape. Stanley wanted to build it out of perspex- 'plexiglas,' I think, is what it's called in America- and make it clear, like a piece of glass."

To investigate the feasibility of building the artifact out of this material, Masters had gone to a perspex exhibition in London during early preproduction. "I went up to the guy I thought looked most impressive, judging from the stuff he had," stated Masters, "and I said, 'I'd like you to

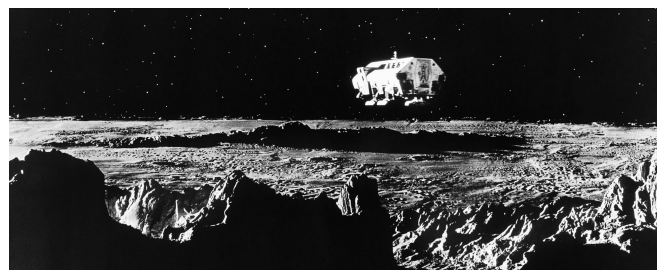
make a large piece of perspex for me.’ And he said, ‘Sure, how big would you like it?’ And I said, ‘It needs to be sort of a pyramid shape and I want it to be about twelve feet tall.’ And he said: ‘My God! That is a big piece of perspex. May I ask what you intend to do with it?’ At the time we were planning to shoot the Dawn of Man sequence on location, so I said, ‘Yeah, I’m going to put it on top of a mountain in Africa.’ And he went: ‘Ah, well. Ask a silly question...’

“We talked about it some more, and he said: ‘Well, we’ve never made anything of this size- I mean, nobody has- but we’d like to do it. For various reasons, though, we can make it best in the shape of a pack of cigarettes, like a big slab.’ So I went back to Stanley, and he said okay. It took a helluva long time for this company to do all of the molding and pouring and everything; and then it took a month just for the slab to cool. It had to cool very slowly; otherwise, it would shatter. After that, they had men polishing it for weeks to get every surface perfect. Then we brought it to the studio and stood it up, and it looked magnificent. So I went and got Stanley and brought him over to have a look at it, and he said: ‘Oh God, I can see it. It’s sort of greenish. It looks like a piece of glass.’ And I said, ‘Yes, I’m afraid it does, Stanley- you’re right there.’ He said, ‘I imagined it would be completely clear.’ I said, ‘Well, it is nearly two feet thick, you know.’ So he just looked at it and nodded, and said, ‘File it.’ ‘Do what?’ ‘File it,’ he said. The thing had cost an absolute fortune, but that was it.”

After some debate, Masters finally suggested that they make the artifact out of wood and paint it solid black- which would make its composition more difficult to ascertain- and Kubrick gave his approval. “We made a black one,” said Masters. “Actually, we made about fourteen black ones. We threw them away just as fast as we made them; because after we finished them, the heat or the moisture or something else would cause slight imperfections in the wood, which were unacceptable to Stanley. We kept making them, using all different kinds of wood, until finally we got one just right. But when Stanley saw it, he said, ‘I can see finger marks on it.’ ‘I know you can, Stanley. I don’t know what we can do about that.’ And he said: ‘Well, there can’t be finger marks on a thing from outer space. Everybody who handles it will have to wear gloves.’ Just keeping it clean was a nightmare, because, for one reason or another, it attracted dust. We’d take it out on a stage and ‘foomp’- it’d be covered with dust. We had to use air blasts to keep the dust off the damn thing. Then we’d put the lights on it- and after three or four hours, I’d be biting my nails, because as it got hotter and hotter you could



Floyd is flown by moon bus to the Tycho crater where the anomalous artifact has been unearthed. Since the shot had no perspective shift, a photo cutout of the moon bus model was composited with the earth and star background. Compositing was executed via the Sausage Factory- an oversize horizontally oriented animation setup, devised by Wally Veevers, that consisted of a fifteen-foot pane of glass mounted on sliding rollers in front of a track-mounted camera. A crude system of synchronous motors offered a degree of repeatability, allowing multiple elements- including projected images- to be shot in separate passes in register.



see slight bumps starting to form along the surface. 'Oh, Christ! I wonder if Stanley will see that.' And if an electrician happened to move alongside and put his hand on it- 'Stop the shooting! Back to the paint shop for a re-spray!' It was unbelievable what went on to protect that thing."

Along with the use of the 6.5mm camera used to photograph the film, the clay which was ultimately used was hand-painted and used as a special effect. A team of 6 people to capture the details of the landscape as a whole, and the landscape that was created was Trumbull's original concept.

With the completion of the moon excavation scene, production moved back to Borehamwood, where construction crews had erected a number of sets, including interiors of the massive Discovery spacecraft. Reasoning that any ship designed to carry human beings into deep space would require some sort of artificial gravity, Masters and his team designed the main crew compartment as a circular centrifuge. "Since it was one of the first things we designed," commented Masters, "the centrifuge set the style for the rest of the film in many ways. It was an easy enough thing to design, but to construct one that worked the way we wanted was a major engineering job; so we got some real engineers- as opposed to studio engineers- to actually build it for us." Construction of the centrifuge, by the Vickers Engineering Group, took six months and cost about an eighth of the production's entire \$6.5 million budget - an enormous amount in those days, which would explode to \$10.5 million by the time Kubrick finished his space epic more than a year past its projected completion date.

"We designed quite a cunning apparatus, really," continued Masters. "The set was created in two halves, like two coffee tin lids held together to form a little round box. If you open the two lids a fraction of an inch, there's a gap all the way around, and the two halves are separate. Then, if you have an axle leading away from each of the two halves- not going right through- you can revolve them independently, but together; and you can revolve them as close together as engineering tolerances will allow. What we had was big - a huge round box standing on end- and it looked kind of like a Ferris wheel from the outside. It was as tall as we could make it on the stage- about thirty-eight feet- yet the slot that divided the two halves was only a quarter of an inch wide. It was just a fantastic piece of precision engineering to get those two halves revolving together with the space between them never varying."

Filming on the set was an arduous undertaking for director of photography Geoffrey Unsworth. "Of course, there was just one place to stand," stated Masters, "and that was at the bottom. As the set went round and round, you had to move around with it- which presented some interesting problems, especially with the cameras. But by virtue of the fact that the set was actually in two halves, we were able to use a little dolly- about two feet long and eighteen inches wide- with the camera mounted on it. A thin blade of steel that slipped right in between the two halves of the centrifuge- and thus held the camera in place



The lunar excavation site set was built at Shepperton Studios, on what was then England's largest shooting stage. The live-action was photographed and then held unprocessed for more than a year so that the surrounding landscape- a miniature not yet constructed- could be added later onto the original camera negative by running a bipacked holdout matte to protect the previously exposed area. The technique- used extensively in

from the outside- supported the dolly itself and allowed the camera to remain fixed in space as the set rotated around. For low-angle tracking shots- like those when Poole is jogging- the camera would shoot into a mirror, so its point of view was right at the floor. Then, for shots where the camera needed to remain in one place, relative to the set, a special rig something like a free-swinging Ferris wheel seat was bolted into position around the centrifuge interior. This allowed the camera operator to tilt 360 degrees and remain in a vertical position as the centrifuge rotated. All he had to do was make sure his feet kept out of the shot, because as he went up they would dangle.”

Unsworth’s first assistant, John Alcott, ‘rode’ the set with the camera operator. “It was a little hairy being up there thirty-five feet,” observed Alcott. “It was like going to a fairground. There was a massive gimbal mechanism to hold the camera. It was a 65mm camera- a sound camera, too, so it had a big blimp on it. The camera was attached to the base and we would sit on it; and as we went up, the movement would be counteracted by the movement of the wheel. Video was linked to the camera so those outside the wheel could see everything we shot. That was the only way Kubrick could see what was happening, because there was only me and the operator and the artist in the wheel. Everyone else would sit outside in a very big wire cage in case anything fell down on them, like lamps, as the set rotated.”

Removable panels were fitted all around the perimeter of the centrifuge to provide the crew with access to the set interior. “All of the lights were built into the set,” explained Masters, “so they went around as well. Every now and then one would blow, and there’d be a shower of shattering glass everywhere. There was no way of cleaning it out; so as the wheel went around, the whole thing tinkled. We also had quite a few 16mm projectors going around upside-down with the wheel, projecting all of the computer readouts.”

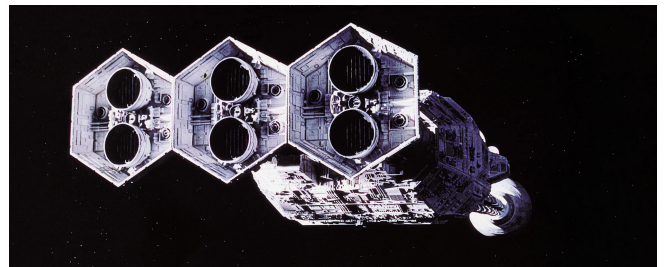
The projectors were rigged by Brian Johncock. Johncock- who later changed his name to ‘Johnson’ and achieved Oscar recognition for *Alien* and *The Empire Strikes Back*- had been working for visual effects veteran Les Bowie when Wally Gentleman approached Bowie for someone to work with him on 2001. Bowie generously recommended Johncock, affording his young protégé an opportunity to work on what everyone knew would be a very big picture. Johncock ended up spending two and a half years on the show.

“Setting up the rear-projection systems for the space wheel was one of the first things I did,” recalled Johnson. “There were seventeen or eighteen screens in the set; and since the whole thing rotated, we had to run everything off slip rings and with remote control of one form or another. The problem was that the set and the screens had been designed without anyone having figured out how they were going to get the projectors into place- the usual thing that happens on a big production- and there wasn’t enough room to fit all the projectors that were needed. Someone had already fashioned a system where mirrors could be used to reflect projected images onto the screens; but when the set rotated, these mirrors bounced around and it was difficult, or impossible, to get the projectors lined up. No one really had an idea of how to

the film- produced a superb first-generation in-camera composite. Though based on scientific projections at the time, views of earth from space were rendered much brighter and more moon-like than the blue orb that would actually be seen when NASA astronauts and cameras at last ventured far enough into space. As the astronauts study the artifact- thought to be of extraterrestrial origin- the monolith unexpectedly emits a piercing electronic signal aimed at Jupiter. After experiments with Plexiglas proved unsatisfactory to Kubrick, Tony Masters and crew built the monolith out of wood and painted it black. Kubrick was adamant that the object be maintained in pristine condition, requiring a fresh coat of paint if so much as a fingerprint appeared on its surface.

make it work until I suggested mounting the projectors base to base- one right-side up and one upside-down. That way we could project right onto the screens, without needing mirrors. Wally Veevers insisted that we couldn't run a projector upside-down because the bulb would burn out in no time at all. That didn't seem like much of an argument- given the circumstances- since the wheel would be rotating, and in the course of one rotation all the projectors would be upside-down at some point. As it turned out, we had absolutely no difficulty running the projectors upside-down. There was a lot of bulb-changing, though, mostly because the wheel vibrated a lot and the filaments just couldn't handle it. We used Bell & Howell 16mm projectors with rapid pull-down and three-bladed shutters so there wouldn't be problems syncing up with the camera. We switched them on and off remotely. I ran some of the film forward and some of it flopped and backward to make it all wind up the right way on screen. We also had to deal with soundproofing. Stanley wanted to shoot dialogue in the set, of course, and the projectors made quite a lot of noise. So not only did we have the problem of actually operating them, we had to blimp each one. I built coverings for them and put fans in to extract the warm air, and it all worked reasonably well."

At one point in the story, Bowman and Poole scale the hub of the centrifuge and enter a revolving hatchway to get from the crew compartment to the command deck, which has no artificial gravity. "To capture that," remarked Masters, "we had a camera at the end of the corridor, screwed to the deck. The men walked away from us toward the revolving set, and as soon as they stepped onto the drum, we stopped it and began revolving the corridor. But because the camera moved with it, you couldn't see any change at all. On the screen, it looked like the end was revolving all the time and the men were going around with it."



Eighteen months after the discovery of the ancient artifact on the moon, the spacecraft Discovery- commanded by astronauts David Bowman and Frank Poole- is en route to Jupiter to investigate clues as to its possible origin. Defying cinematic convention as to what a spaceship should look like, the Discovery was designed as a long, spindly vessel with huge nuclear engines at one end and a spherical command module at the other. A fifty-four-foot-long model of the spaceship was mounted on stationary steel supports and lit with a high-key source to simulate unidirectional illumination from the distant sun. Shutter speeds of several seconds per frame were required to hold full depth of field on the model, and incremental camera movement over a 150-foot track suggested the ship's passage through frame.

Kubrick, whose understanding of mechanics was minimal, had trouble envisioning the dual-rotation corridor when it was presented to him in theoretical form. "The mechanics of it were quite complex," stated Masters, "and I had an awful time trying to explain it to Stanley. He didn't really have a visual imagination and could only understand what he was going to get when he saw it finished. There was a blackboard in his office; and I'd scratch away on it for hours on end, trying to explain how we were going to do things. On this particular set, it took me until about one o'clock in the morning, and he finally said: 'I think I see it! I think I know what you mean.'" Equally maddening for the designer was Kubrick's tendency to dislike any set he saw in a partially completed state. "If he saw anything halfway finished, he'd want to change it. 'But Stanley, we haven't painted it yet. We've still got to do all the dressing.' He couldn't imagine how it was going to look. When he walked onto the finished set, however, it was different- he would say, 'Oh, fantastic!' We used to hide sets from him until they were finished, and then hope that he would like them."



Exercising to stay fit during the long journey, Poole jogs and shadow-boxes around the command module centrifuge, which rotates to create artificial gravity. The revolving set- designed by Tony Masters and constructed by an outside engineering firm- stood nearly forty feet tall.

One of Masters' favorites was the huge subsurface airlock on the moon where the spherical Aries spaceship lands. "I showed Stanley my sketch of it," recalled Masters, "and he said: 'Well, I don't know. How could we shoot that? How would we make it?' So I told him I thought we could make it as a kind of miniature, about twelve feet long. But he was worried about how we were going to get all the people working in the little control rooms in there, and finally he said, 'I don't think it will work.' He just wasn't at all keen on the whole idea. Well, I decided to go ahead and build it anyway. It was at the plywood-and-nails stage when Stanley found it one day. 'What's this?' I said: 'Oh, well- this is the airlock. I have an idea it might work.' 'Oh, God, no. I told you we're not going to do that. It won't work.' I said: 'Okay, Stanley. But if I get any spare time, I might fiddle about with it some.' 'I shan't shoot it, even if you do.' Well, I persevered on that sonofabitch for months. We finally got it sprayed, and I put Harry Lange on it for the finishing touches. It was complete- or very nearly complete- when Stanley discovered it again. 'Oh, gee,' he said. 'It doesn't look bad, does it?' And before you knew it, he was so enthusiastic about it that he shot it, and it turned out to be one of the best shots in the film."

While Harry Lange was responsible for most of the spaceship designs, and Wally Veevers oversaw their construction as miniatures, ultimately, nearly everyone in the effects department had a hand in the model-building effort. "We were all involved to one degree or another," affirmed Trumbull, "but I don't think any of us realized, at the beginning, what a big job it was going to be." In fact, model construction, initially, was intended to be an outside job, with production engaging an independent contractor in London to do the work.

The first model to be delivered was the moon bus- a boxy vehicle which transports Heywood Floyd and his colleagues to the site of the lunar excavation. "It was a well-executed fiberglass shape, about two feet long," noted Trumbull, "and it was built to our specifications- but in

terms of detail and believability, it was nowhere. So I started sticking little plastic model kit parts all over it, along with ping pong balls, pieces of picket fence- all kinds of junk. I also scratched in fine lines and made little panels and built up antennas. It was a collage of all sorts of things, just to create surface detail. That idea really grew out of stuff we had done back at Graphic Films where we made up a number of spacecraft using plastic model kit parts."

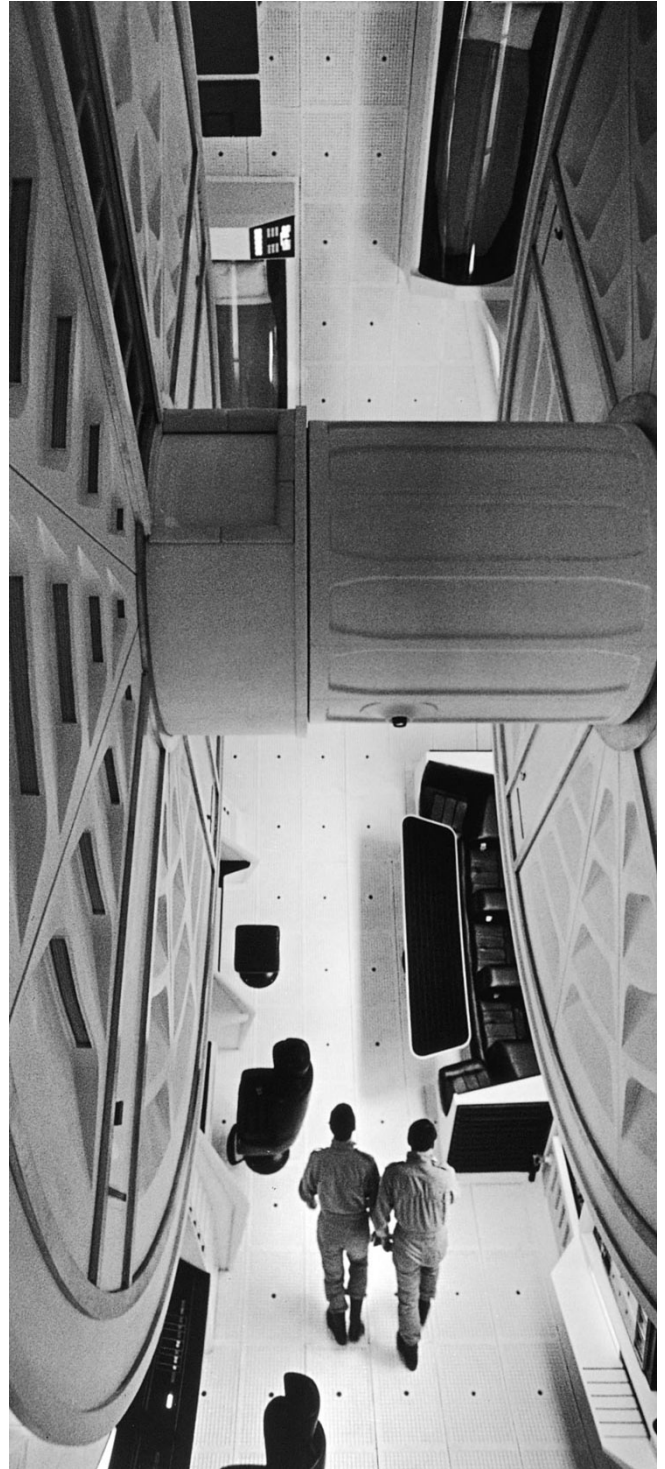
The next model to come in- the two-foot-diameter Aries- was similarly unsatisfactory. "We did an enormous amount of work on that," said Trumbull, "building articulated, motorized landing legs, cowlings that folded out, and other moving parts. Then came the Orion- the long, sleek aerospace craft- which was about three and a half feet long. From there we got into the eight-foot space station model, which was built at the studio out of fiberglass, brazed brass and steel. It was very detailed, with slip-ring commutators to get electricity out to the lights, which had to be able to rotate, and then air vents and ducts to pipe cooled air in to keep the bulbs from burning up and melting the model."

The final model to be delivered from the outside vendor was the huge Discovery spaceship, which Harry Lange had designed early on. "We all grew to hate that design," remarked Trumbull, "and were working on the side to come up with something else. It had a large round ball at one end for the crew, with sort of a slotted window and three holes where the pods came out- and that remained pretty much intact. The rest of it, though, was a dart-shape winged thing, with huge heat radiators for nuclear power. That design was actually built by this model company and then discarded. It wasn't until Con Pederson and I sat down and started working up some designs involving a whole bunch of modules and a big nuclear engine at the other end that we were all able to agree on a basic look. Then Harry Lange took our rough idea, finished it off and redetailed it."

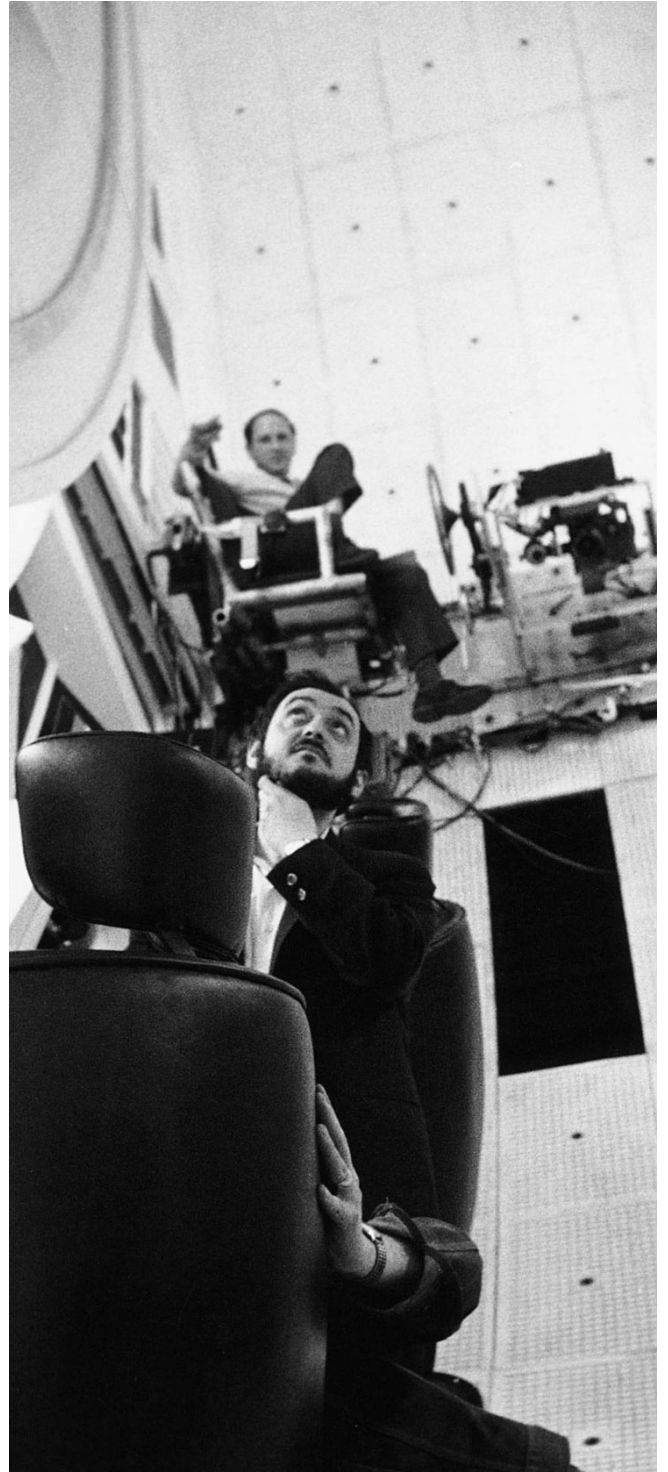
The primary model derived from that design measured fifty-four feet in length. "Once we got that one," said Trumbull, "we had two or three crews- mostly young design students- who would come in and do the incredibly laborious job of applying plastic model kit parts onto the basic shape." A fifteen-foot-long version was also produced, making the Discovery the only ship in the show constructed in more than one scale. "The only way we could get the real long shots of it- and there are just one or two in the film- was with that shorter model."

By early summer 1966, Kubrick had been shooting for six months- but 2001 was far from complete. Still to be done were nearly all of the visual effects shots, plus some additional live-action sequences; and, even at this late date, many essential story points had yet to be pinned down as Kubrick continued to revise and rethink every aspect of his movie. "Throughout principal photography," remarked Tony Masters, "we weren't working to any particular schedule or even any particular script. We had a basic idea- which was, of course, Arthur Clarke's story- but we never really had a finished script. We worked through the movie, changing every day our ideas of what we were going to do tomorrow. We'd get together with Stanley in the evening and talk about what we were going to do the next day- and as a result, the whole thing would change. The production department was suicidal because, daily, absolutely everything that had been planned would be thrown straight out the window- we'd do something completely different. And that was how we worked from day to day. It was a nightmare for the actors because all the dialogue they had learned was completely different the

next morning. They didn't even know what set they were going to be on. But that's how it was done. We just sort of made it up as we went along."



Bowman and Poole walk the inside surface of the centrifuge. Construction of the set took nearly six months and consumed an eighth of the production's original budget.

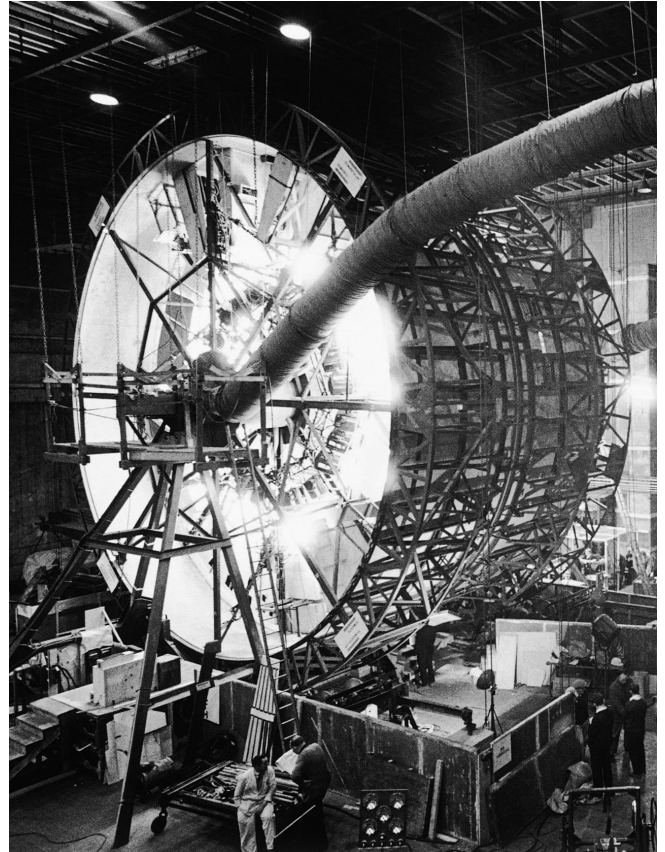


Kubrick contemplates a shot inside the centrifuge as camera operator Kelvin Pike awaits at his elevated camera station. To ensure that the camera remained fixed in place as the set rotated past it, it was mounted on a dolly attached to a rigid steel blade inserted between the two independent halves of the spinning wheel. Other shots had the camera attached to a point on the rotating set or aimed into a mirror to maintain a floor-level point of view.

Due to a previous commitment to another picture, Geoffrey Unsworth departed the production that summer, leaving John Alcott behind to finish up. Alcott- who would go on to have a long and fruitful relationship with Kubrick, serving as cinematographer on *A Clockwork Orange*, *Barry Lyndon* and *The Shining*- rose admirably to the occasion. "When Geoffrey had to leave," recollected Alcott, "Kubrick asked me if I'd care to take over the rest of the film. At that point, most of the live-action material had already been completed; but there was still all the exterior space stuff to do, as well as the Dawn of Man sequence, both of which I shot. We'd already been filming for six months, but it was another eighteen months before we finished."

The Dawn of Man prologue alone- the last of the live-action to be shot- consumed three full months of the schedule. Long before filming on that sequence commenced, Kubrick engaged makeup artist Stuart Freeborn- who had produced the makeups for Peter Sellers' multiple characters in *Dr. Strangelove*- to design and create The Man-apes required for the sequence. "I still have the letter I received from Stanley Kubrick regarding 2001," recalled Freeborn. "It said: 'An interesting makeup film. Schedule- five months, maybe six.' Well, I was on it for more than two years. But that letter was the beginning of it."

At the start, Kubrick envisioned the Dawn of Man hominids as more man than ape- something akin to the Neanderthals that ranged over Europe and parts of Asia tens of thousands of years ago. "The problem with that idea," related Freeborn, "was that the Neanderthals would have body hair, but rather sparse and covering only certain parts of their bodies. So, essentially, they would have been totally nude- which would have made them difficult to shoot. When Stanley first realized it was going to be a problem, he said: 'That's all right. Either I'll shoot them from the waist up or go back far enough that you won't be able to see anything.' But since, typically, eighty percent of shots are full-length, that wouldn't have worked. He was still going to need full-length shots, no matter what. So we did a test, trying to cover up crotches, male and female, with sparse, short hair in such a way that you wouldn't notice anything. We lifecast the performers' crotches and made these little plastic coverings, and added hair to them on this special lace used for wigs. We did it quite well- and in fact, you didn't really see anything- but the problem was that the



Large air conditioning units were used to dissipate the build-up of heat from the high-intensity practical illumination needed for photography. Because of the nature of the set- and the fact that no one could stand in it except at the bottom- only the actors and camera operators were allowed inside during the filming. Kubrick, Geoffrey Unsworth and other essential crew members remained outside- in a wire cage to protect them from falling debris- watching the interior scene on a monitor by way of a video link to the film camera.

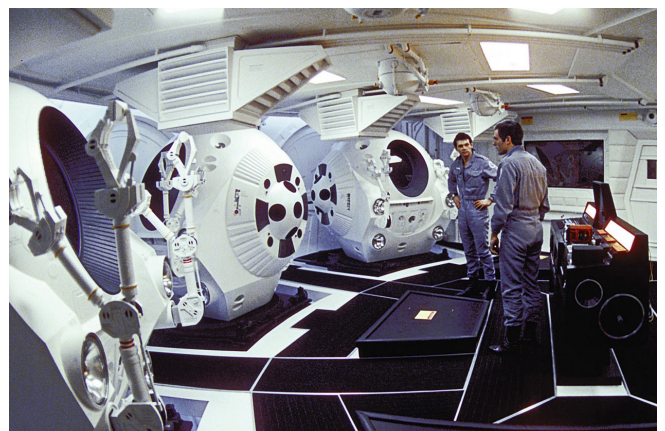
characters looked completely neutered. The essence of the picture was that the aliens came down to earth to make sure that these man-apes would not die off because of famine and whatnot. The aliens knew that these were the only creatures on the planet that might eventually become like themselves- and they needed us. Obviously these creatures had to procreate to continue the species- but it was pretty clear that wasn't going to happen with the creatures we came up with. The only solution was to go back another million years or so- to ape-men rather than man-apes. That way they could be covered entirely with hair."

The retreat back in time also solved the problem of having to apply subtle prosthetic makeups to human performers, since the more ape-like creatures could be created through complete masks. "The first idea would have required makeup men with a lot of experience working with foam pieces," related Freeborn, "and there weren't any other makeup people in England at the time, to my knowledge, who did prosthetics of this kind. Even if there had been, these prosthetics would have taken about four and a half hours to apply, because not only would the face have to be done, but also the hands and feet and the whole body. It would have been a huge job- especially with sixty performers, which was the number Stanley originally intended. That number eventually dropped to twenty-six; but, still, it would have taken a small army of makeup people to do it. So I'm thinking: 'How am I going to do this on my own, really? I'll never be able to train enough people- not sixty of them. I haven't got time.' I had to think of something entirely new."

That imperative led to the development of a separate, fully articulated creature head- the first ever employed for a movie. "The idea was to make an entire head that could be put on in seconds and taken off in seconds," explained Freeborn. "Up to then, whatever you put on had to stay on all day. The performer had to eat in it, drink in it, smoke in it, or whatever- and he would get very uncomfortable after a while, especially under the lamps, which were much hotter in those days than they are today. A separate head that could be taken on and off was a tremendous breakthrough."



Like the centrifuge crew quarters, the command deck of the Discovery featured multiple viewscreens onto which were rear-projected animated graphics and readouts from the on-board HAL 9000 computer. The graphics- primarily graphs and charts xeroxed out of scientific journals and then blown up into high-contrast negative transparencies- were shot by Doug Trumbull and animator Bruce Logan on a makeshift animation stand consisting of a camera clamped to a metal frame over a work surface of backlit glass. Since the crude setup could not be raised or lowered in relation to the artwork, as a true animation stand would, vertical camera moves were simulated through the use of a zoom lens.



Poole and Bowman in the Discovery pod bay. The scientifically sound pods and spacesuits- as well as many of the ships- were designed by former

NASA designer Harry Lange, who joined the show as a technical consultant, but ultimately earned a credit as production designer.

Freeborn took lifecasts of the twenty-six performers- all of whom were male, even those who would be playing the female members of the ape clan. "For some reason," stated Freeborn,

"Stanley just felt more comfortable with the boys." From those lifecasts, Freeborn produced rigid urethane underskulls that fit each performer's facial structure exactly. Rather than encase the performer's head entirely, this underskull was essentially a faceplate that attached at the back of the head via two velcro straps. Those straps would ultimately be covered by a long wig, built in two halves, which snapped together and onto the body suit to secure the headpiece. "The facial part went all the way up to the top where the wig joined it, about to the crown, then came in front of the ears."

A foam rubber mask went over the urethane face plate. Each was crafted individually by Freeborn, who worked over a positive plaster casting of the performer's head, with the rigid urethane mask on top of it. "The two things I had to think of were the age and the character of each particular ape-man," related Freeborn. "I tried to fit the personality, the shape, the expression and the age of the face I was modeling to the particular performer- I knew all of them fairly well at that point. I knew their personalities, which ones moved quite fast, which ones were slower in their movements, and so on. In addition to that, I had to consider how the foam rubber would react as the mouth opened and closed. I had to be careful about how much stretch I was going to need in it and how it would affect different parts of the face. These faces had quite a few wrinkles in them, and I arranged some of those wrinkles conveniently so they would unfold to facilitate the opening of the jaw and mouth."

Only the performer's eyes were visible once the mask was in place. "We had to glue the edges of the mask- which were very fine- close to the eyes," remarked Freeborn. "The glue we used never dried- it was sticky and stayed sticky- so we could pull the mask off when we needed to without tearing the edge, then be able to press it back on again and have it stick sufficiently. We applied a little dark makeup around the eyes because we couldn't get right up to the eye with the mask. That was all the makeup we did, because that was all you ever saw of the human flesh. We would put the mask on and do the makeup around the eye in just a minute or two."

All twenty-six heads had articulated jaw pieces. "We made the jaw so it had a chewing movement," said Freeborn. "A simple hinge would have looked terribly phony. These characters were going to be eating; and they had to chew sideways, not just up and down. Also, they needed to be able to make different expressions, and those would look more natural if the jaw could move side to side. I made a special chewing hinge that could be popped on and off with snaps- so if anything went wrong, we could rip one out and put another one right in."

A tension-sprung mechanism in the mask kept the jaw closed until the performer opened it through the use of his own jaw muscles. "For the performer to open the jaw," stated Freeborn, "he would have to stretch the foam rubber on the sides of the face, which was difficult enough. In addition, he would need to pull cords and toggles to open the lips, top and bottom. So the performer's jaw muscles really had to work to open the mouth of the mask. Then the mouth had to come back and close- which it did not want to do. We found that it would hang open a bit-

both the jaw itself and the foam rubber mask on top of it- which looked silly. The problem was that once the rubber stretched and loosened up, no matter what we did, the mouth would never snap shut again with just the tension of the foam rubber cheeks. So we had two separate problems- making the jaw snap shut and making the foam rubber over it snap shut. Springs were out because they make such a noise and they're awkward to use. Elastic bands worked great for the first part of closing the jaw- but at about the halfway mark, they would get very weak and wouldn't close all the way.

"Finally I tried using deep-field magnets, hidden in the teeth, so that when the elastic band began weakening, losing its power to withdraw back, the magnets would take over and shut the jaw the rest of the way. At first, I found that if the magnets were positioned exactly flat, facing each other, it was a helluva job for the performers to break that magnetic field and open the jaw. I solved that problem by tip-tilting them slightly. The magnets still had their power, but by putting them at a slight angle, there was enough give that the performers could open the jaw quite easily. It made all the difference." Magnets were also used to close up the loose foam rubber part of the mask.

Once Freeborn had the masks perfected, Kubrick came by to have a look at them. "One thing I liked about Stanley," related Freeborn, "was that if it seemed you accomplished something easily or quickly, he would always ask for more. He wouldn't let you get away with that. He figured: 'If this bugger can do this, he can probably do more.' So he came back, after looking at our apes, and said: 'Right, I've been thinking about this. Now I want to see them snarl with their jaws and teeth closed.' I thought, 'How the hell am I going to do that?!'" Freeborn met the challenge by adjusting the closed-jaw configuration of the mask so that the performers could just slip their tongues between their teeth to operate toggle mechanisms. "By pushing on the left toggle, they would lift up the left part of the lip; by pushing on the right toggle, they would lift up the right part of the lip. By rolling the tongue from one to the other, they would produce a snarling action. It worked beautifully."

Kubrick tossed Freeborn another curve when he announced his intention to shoot a scene with the ape-men devouring raw meat from a kill they have made. "I knew that the fat in the meat would destroy the rubber of the masks in a matter of minutes," stated Freeborn. "So I made chunks of meat out of plastics- something that resembled meat exactly, but would not damage the foam rubber. Of course, when I mentioned this to Stanley, he said, 'No, I want real meat.' Well, that meant making a lot of extra masks. It took about eight hours to do each one- mixing up the foam rubber, pouring it in the molds, cooking it in the oven and taking it out. I had to have three crews working eight-hour sessions all through the day and night in order to have a constant supply of new faces to replace the masks as they wore out."

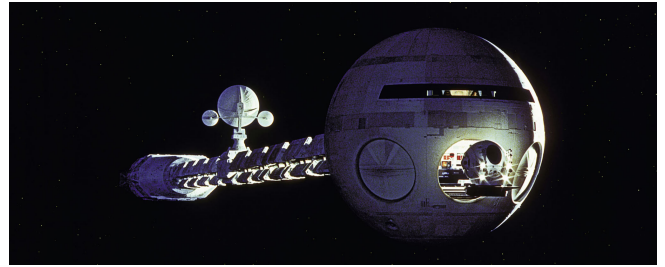
In addition to the heads, Freeborn was responsible for designing and building complete suits that would cover the performers' bodies. "At first, when we were going with the more human man-apes idea, I wasn't going to make full costumes," recalled Freeborn. "We weren't going to make false feet or false breasts or false hands or any of that. There was just going to be a little hair on bits of lace that would stick on in parts- a simple job. But once we went to the ape-men idea, it became necessary to make a whole costume. One of the problems was how to make costumes that could be padded a bit to look like monkeys, and yet still be flexible enough to

perform in. We realized that real skins of any kind were totally useless, because they were all the wrong shape, and so rigid they would be impossible to move in. So I came up with a completely new idea- one that's been used a lot since- which was knitting the costume."

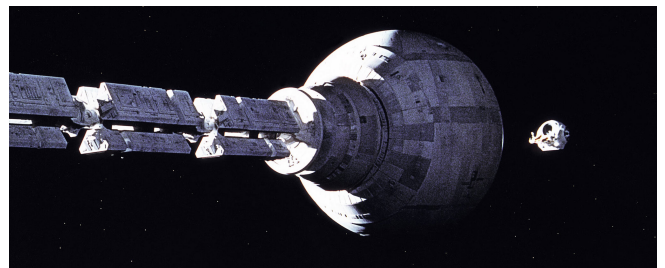
Freeborn used angora wool for a test costume, since he had arrived at the notion upon inspecting an angora jersey. "When the angora was brushed with a wire brush, you couldn't see the knitting underneath- all you would see was this short fur. So I thought: 'This is nice and flexible- much more flexible than a skin. If only I could get hair into that.' Then I suddenly visualized knotting hair, like we do a wig, into this wool. 'What if I use human hair in parts of it, and then perhaps yak hair, and finally horse hair for the coarsest area down the spine?' By doing that, I could design- texture-wise, color-wise, shape-wise- a whole skin to suit a particular animal, no matter what kind. It seemed like an ideal system- and I've used it ever since."

Learning that angora was cost-prohibitive, Freeborn settled on less expensive wools that would brush up in much the same manner. He then contacted some wigmakers and proposed the idea of knotting hair into the knitted fabric. "The wigmakers went crazy," remarked Freeborn. "They said it wasn't possible. I said, 'Well, it is possible because I have a sample of it that I've done myself; and if I can do it, your experienced wigmakers can certainly do it.' So they said, 'Oh, well, send it down then, and we'll have a go at it.' So I sent it down to them- and they took it from there, very quickly getting into it." The technique- which Freeborn would use years later to make Chewbacca for the Star Wars series- resulted in a natural-looking fur suit for the ape-men. "It was a great solution. The costumes were lightweight, airy, comfortable to wear, and they fit perfectly."

The fur suit was worn over a padded polyurethane undersuit that reshaped the performer's anatomy into a more simian likeness. "We made up a kind of vest fitted especially for each performer," said Freeborn. "On that vest we adhered shoulder pads and a back pad to create the monkey shape, and any other little bits and pieces that we needed. The costume fit over those paddings. Most of it was this knitted wool and knotted hair, but in some areas we wanted more foam



One of the Discovery's pod bay doors opens to release a pod carrying Bowman, who sets out to remove the AE-35 unit- identified by HAL as defective- from the antenna assembly midway down the ship. The miniature shot employed a thirteen-inch-diameter pod mounted to a mechanical launch ramp that slid out of the six-foot-diameter command module. The interior of the bay was a large still photograph of the live-action set, positioned inside the miniature. Footage of Poole monitoring from within the spaceship was rear-projected, on a second exposure, into the command deck window area.



Wherever possible, Kubrick insisted that multiple elements be combined in-camera, on original negative, to avoid the image degradation inherent in optical compositing. Since there were no multipass or bluescreen traveling mattes employed, a team of rotoscope artists spent more than a year executing the hand-drawn bipack holdout mattes required to add painted star backgrounds to shots of ships in space. The starfields- airbrushed by Doug Trumbull and photographed on the animation stand- often included stars with subtle yellow or blue coloration.

rubber- in the breasts, for example- and we would knot sparser hair right into the foam rubber. We would glue the foam rubber pieces onto the wool, then knot the hair into them. We attached velcro all the way down the back, so the suit could be closed up very easily.”

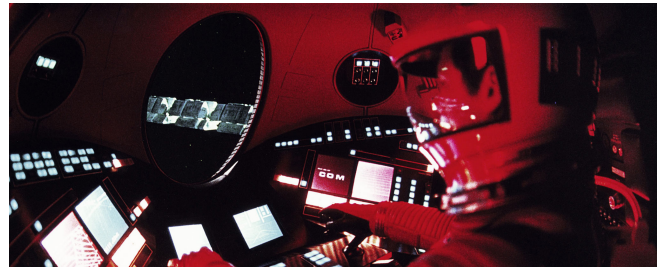
Separate pieces included gloves that extended the arms and hands of the performers to ape-like proportions. “Instead of just having gloves from the wrist down,” commented Freeborn, “I made cotton gauntlets that went all the way to the elbow. We modeled the extended hands using foam rubber and attached them on top of the cotton with velcro. The performers could put them on and take them off themselves, very quickly and easily. The extensions weren’t articulated because I’ve always been against using mechanics unless it’s absolutely necessary. I try to make everything tied to the human movement underneath. The performers’ hands came down to about the middle knuckle of these extended fingers; and the last two joints extended beyond the tips of their own fingers. But the performers were able to create sufficient movement just by moving the tips of their own fingers- they couldn’t move the entire extended finger, but they could move enough of it. They could even grip things- such as when the main character grabs the bone to use as a weapon.”

One of the biggest challenges of the assignment was for a series of shots- ultimately cut from the film- in which baby apes would suckle from their mothers’ breasts. Freeborn surmised that since human babies could not be subjected to makeup applications or life-casting he would have to create some sort of foam rubber doll with lead wire inside to enable him to position the limbs and affect the look of a baby clinging to its mother. It was a reasonable solution- but Freeborn suspected, based upon past experience, that Kubrick would never go for it. “It was cheating- and Stanley didn’t like cheating- so I knew I had to have something else up my sleeve. I thought maybe I could use baby chimpanzees- cover their enormous ears with more human-looking ones and then do a makeup over their very pink faces. I wasn’t about to bring that up first- but if Stanley balked at the doll idea, I would tell him the only alternative was to make up baby chimps, supposing we could get a baby chimp anywhere near us to do this.”

Freeborn decided to sit tight until Kubrick broached the subject. “Finally he rang me one day, and said: ‘By the way, I hope you haven’t forgotten, but in two or three weeks’ time we’ll be getting to the family sequences where we shall want to see the babies suckling from the mothers’ breasts. How are you going to do that?’ I outlined the idea I had about making the foam rubber dolls; and he said, exactly as I had imagined he would: ‘That’s no good. I want to see them suckling at the breast.’ So I told him my other idea. ‘But it’s a question of whether or not I can make up some real baby chimps, you see.’ And he said: ‘That’s good. I like that idea. How are you going to make them suckle from the breasts?’ I said, ‘Well, I’ll put a little bit of honey on the foam rubber teats and let them suck that off.’ He said: ‘No, that’s no good. They’ll suck it off too quickly. I want to see them really suckling.’ And I said: ‘Oh, I see. You want practical, working breasts.’ And he said, ‘Yes!’ So here we were, getting in deeper and deeper.”

Freeborn first investigated the possibility of acquiring baby chimps from Chipperfield’s Circus, which had supplied animals to motion picture companies for years. “Mary Chipperfield was in charge of all of the animals that they brought down to the studios,” stated Freeborn, “so I phoned her up, and said: ‘Mary, I’ve got a problem. Do you happen to have any baby chimps?’ She said they did. ‘Do you have the mums with milk and everything?’ And she said, ‘Well, we do

bring up baby chimps, but they only know how to drink out of plastic cups.’ I said: ‘Oh, God, please. Don’t tell Stanley that. Somehow I’ve got to use baby chimps– that is, if I can make them up, and if you can lend me a couple that we can get friendly with so they’ll trust us, and if I can make practical foam rubber breasts that they’ll feed from.’ I knew that if we were going to do this, I was going to have to fool those little devils. The breast would have to look and feel just right; the mechanical action and flow of the milk would have to be just right; the taste and smell and consistency of the milk would have to be just right. On top of that, the milk couldn’t come out when we didn’t want it coming out– it had to come out only when the babies suckled at the breast. But what the hell did I know about the mechanics of a real female chimp’s nipples?



Bowman directs his pod past the Discovery fuel and cargo modules toward the antenna assembly. Window imagery– photographed later with models– was matted onto live-action held takes during postproduction.



Bowman leaves the pod and makes an untethered spacewalk to the antenna assembly– one of the few scientifically unsound events in the picture. Footage of the ship model was composited in-camera with a full-frame film element of a wire-flown suited stuntman projected onto white cardboard and rephotographed using an adaptation of the Sausage Factory machine.

"Anyway, Mary sent over a couple of baby chimps-named Johnny and Timmy, if I recall correctly-with their trainers. My wife and I would carry them around like real babies, so they got very friendly with us. We put these suits on them, just to get them used to that; and then, after a couple of weeks, we tried making up their faces. They sat very still while we did the makeup over the pink area and while we folded their ears back and put on these false ones. Then we let them go- and they went straight up to each other and started licking the makeup off. They just loved the taste of it. So we had to smack their little bottoms, then take them back and remake them up. Eventually they learned not to lick the makeup off.

"After we got all the mechanics worked out, we offered them the false breast and they actually took milk from it. I had figured out how to make a breast with a bladder in it that would push the milk out of a foam rubber nipple with five holes in it. I got one of those syringes they use for inoculating cows- a big one- and with an extra-thin needle we could reload the breast very quickly through one of the holes in the nipples."

Everything worked perfectly- at least in the makeup studio. "The next Monday," said Freeborn, "when Stanley was going to shoot the scene, we loaded up the boys with milk, got them all ready, made up the baby chimps and sent them all down to the set. For some reason, however, Stanley decided to shoot something else that morning. Instead of feeding the babies, he had the performers jumping and rolling around- which churned up the milk in their breasts. On top of that, it was getting very, very hot, and the milk began separating into butter and watery liquid; and after a while, every time the apes jumped, it would squirt out of their nipples. Stanley, of course, did not see the funny side of that at all. He said: 'Oh, God. This is no good. Get them out of here.' So I had to take them back to my lab and clean them up and then fix them again with a new load of milk. Then we went down, and Stanley shot them and it was fine- but, of course, it was all cut. You do see one baby going up to the breast, but that's about it. In the end, there was no need for any of that work at all."

To ensure that the ape-like behavior was accurate throughout, Kubrick and Freeborn - in addition to lead performer and choreographer Dan Richter- committed to memory a National Geographic documentary by primatologist Jane Goodall. "We had a copy of that film," stated Freeborn, "and we ran through it again and again and again, studying every little movement of every chimp- the old ones and the young ones. Dan would have the whole team of performers watching it, and then they'd go off and rehearse all day long to get the movements just right.



Bowman extracts the AE-35 unit from the antenna assembly. A wire-harnessed stuntman and full-size antenna prop were filmed against black for the scene. Back on board the ship, an examination of the AE-35 reveals no defect- but calls into question HAL's reputation for infallibility. The decision is made to have Poole reinstall the unit to see if it actually fails.

Sometimes, they would spend entire days at the London Zoo, watching apes and chimps for real.”

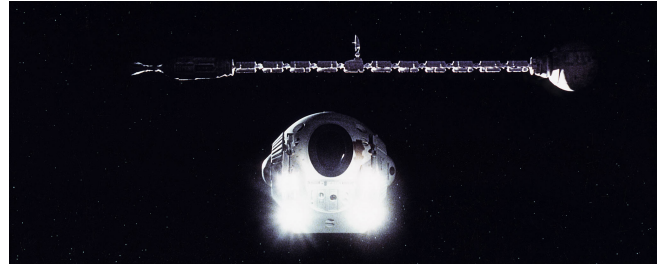
The original plan had been to film the Dawn of Man segment in the Namib Desert of South West Africa (now Namibia)- but that notion was rejected, ultimately, due to logistical problems and Kubrick’s well-known aversion to flying. “Shooting in Africa would have meant all of us going in a boat for three weeks,” observed Tony Masters. “We did talk about it- putting the cutting rooms on the ship and actually editing the picture while we were on the way. It was quite ridiculous.”

An ambitious and unprecedented alternative was to go with front projection on stage, marrying the simian performers and a few choice set pieces with still photographic plates shot on location. It was an elegant idea- but a radical one since front projection, largely unproven at the time, had been utilized only experimentally in feature films. Never before had a major movie sequence depended upon it. Properly employed, however, front projection was more versatile, and produced appreciably better results, than traditional rear-screen process photography. It also circumvented fringing and other undesirable side effects inherent in bluescreen photography, which was far from perfect at the time. The process itself was an offshoot of an extraordinary material- called Scotchlite- devised by the 3M Company for use on highway markings and signage. This hyperreflective material, when applied to a fabric backing, produced a screen surface capable of returning nearly one hundred percent of all light projected onto it- but only unidirectionally toward the point of origin. Consequently, in order to apply this phenomenon photographically, both projector and camera needed to be positioned at exactly the same spot- a physical impossibility handily side-stepped by the use of a beam-splitter to align the projected image along the focal plane of the camera. With that configuration, the image returning from the screen was so brilliant that the intensity of stage lighting needed to balance set pieces and performers in front of the screen completely obliterated that portion of the plate projection falling upon those obstructions; and since camera and projector were in perfect alignment, the foreground elements themselves concealed any unwanted projection shadows they might otherwise have cast on the screen. By applying this technology to the Dawn of Man sequence, Kubrick could have foreground set pieces built in front of the front projection screen and combine his live-action- in-camera and without mattes- with background imagery photographed a continent away.

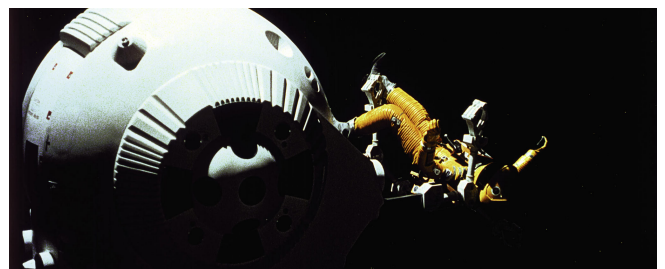
“Front projection was the only way to do this sequence,” insisted John Alcott, who lit and shot the setups. “It would have been impossible to move the entire unit out to Africa, which is where the ideal locations were. And to get those apes to work perfectly out there would have taken far longer than it did by working under the controlled conditions of the studio. It had already been announced that we were going to shoot on location, but we later learned that it was going to cost something like a million pounds just to build the accommodations for the unit. It was just out of all proportion.”

Tony Masters suggested that Ernest Archer- who had been elevated to full production designer in the course of the show- be sent to Africa with a still photographer to shoot the backgrounds on large-format 8x10 transparencies. "Stanley thought that was a fine idea," remarked Masters, "but he had concerns. He said: 'How will I know what you're looking at, Ernie? I mean, how will I be able to tell if you're shooting the right thing?' And Ernie replied: 'I don't know, Stanley. You can't, really. Just leave it to me.' 'Oh, no. God, no. I'm not going to know what you're doing. I'll tell you what- ' All of a sudden he gets enthusiastic. 'Here's what we do. No matter how far out in The Wilds you are, there's always a village with some drums or something, and you can send a message back to the capital where they have phones. What you do is you have a piece of glass on the back of your camera with graph lines A-B-C across the top and 1-2-3 down the side, and you draw the scene you're looking at and call it over to me- A-3, B-9, and so on. I'll be in the office back here in England with my graph, and I'll be drawing it, too. Then I can look at it and tell you: "Yes, that's great. But Ernie...three feet to the left." ' Ernie looked at him, and said: 'Stanley, it's never going to work, you know. You can't do something like that!' And then we all laughed. It was madness- but out of the madness came a lot of very good ideas, too."

In preparation for the Dawn of Man shoot, Tom Howard spent months analyzing and overcoming the technical obstacles inherent in fashioning a front projector that would be capable of handling the 8x10 transparencies Kubrick deemed necessary to achieve sufficient image quality. The carbon arc unit proved to be enormously heavy and spewed out a tremendous amount of light-together with a tremendous amount of heat. The projection screen- roughly one hundred feet long and forty feet tall- was surfaced with irregularly shaped patches of Scotchlite material to disguise and blend the connective seams. Since neither it nor the front projection system was even remotely portable, both were aligned to each other on a dedicated stage and fixed into place for the duration of the shoot. Rocky desert foreground settings- designed by Archer to complement the African background stills photographed by Pierre Boulat and Keith Hamshire-



As Poole tries to replace the AE-35 unit, his air line is deliberately severed by a pod claw at the direction of HAL, who has suffered the computer equivalent of a psychotic episode. Without taking time to don his space helmet, Bowman climbs into a reserve pod and launches it in a fruitless attempt to rescue his shipmate. Since it was impossible to get far enough away from the fifty-four-foot Discovery model to achieve a full profile shot, a smaller fifteen-foot model was photographed as a still. The Discovery was the only ship in the film built at more than one scale. Footage of one of the full-size pods was composited in-camera into the foreground of the shot.



Arriving too late to render aid, Bowman manipulates his pod's arms to retrieve Poole's body. Though the character would be lifeless, and thus immobile, Kubrick insisted that a stuntman- rather than a dummy- be suited up and suspended from wires for the scene, to ensure that the body floated with a convincing sense of limp articulation.

were constructed on a turntable, ninety feet in diameter, which allowed them to be rotated for proper orientation to the screen, regardless of the desired camera angle.

Before committing wholeheartedly to it, Kubrick insisted on thorough testing to ensure the feasibility of the front projection approach. "Many, many tests were done," related Alcott. "With Kubrick, you make sure it's right. You don't do anything unless it is perfect, because he won't accept anything less. Anybody else would have given up before they started, if you'd said: 'Oh, we're going to build a screen this large and front-project still plates on it.' But Kubrick never gives up- and he never gave up on this because he knew it was going to be impossible to do it any other way."

Stage lighting was of the utmost concern during the testing period, since inconsistencies between the lighting on the projected plates and that on the foreground sets and characters are what usually give process photography away. "If you have a background that's lit by one particular light- such as the sun- and you try to match that light in the studio, it's a problem because you don't have the sun and the sky," stated Alcott. "All you can do is attempt to re-create it- and that isn't easy at all. Kubrick asked me, 'How are we going to do that?' And I said, 'The only way to do it is to make the entire ceiling of the stage a big white sky.' So I hung mushroom reflective-type globes from the ceiling- 500-watt photo-floodlights- and I covered the complete ceiling area of the stage with those, which worked out to about two to three thousand bulbs." The problem with this approach- as Kubrick pointed out- was that set pieces would be changed from scene to scene and that the higher mountainous sections would be closer to the bulbs, and therefore hotter than other, lower areas of the set. "He said, 'We'll have to turn bulbs off over the mountains.' I said, 'Well, the only way to do that is to have every bulb on an individual switch.' So he said, 'Okay, put every bulb on an individual switch.' Normally, you'd never get anyone to go along with that. If you said that to a producer now, he'd say, 'You're bloody crazy!' And it was ridiculous. But Kubrick wanted the lighting to be true and real; so we had a switch for every light, and I was able to control every bulb on that set. I could light the ground level fully and then have perhaps only two or three bulbs lighting the higher areas. The heads of the departments hated the idea because it made a lot of work for them; but they made a switch for each light, which required something like eight miles of electrical cable, all together."

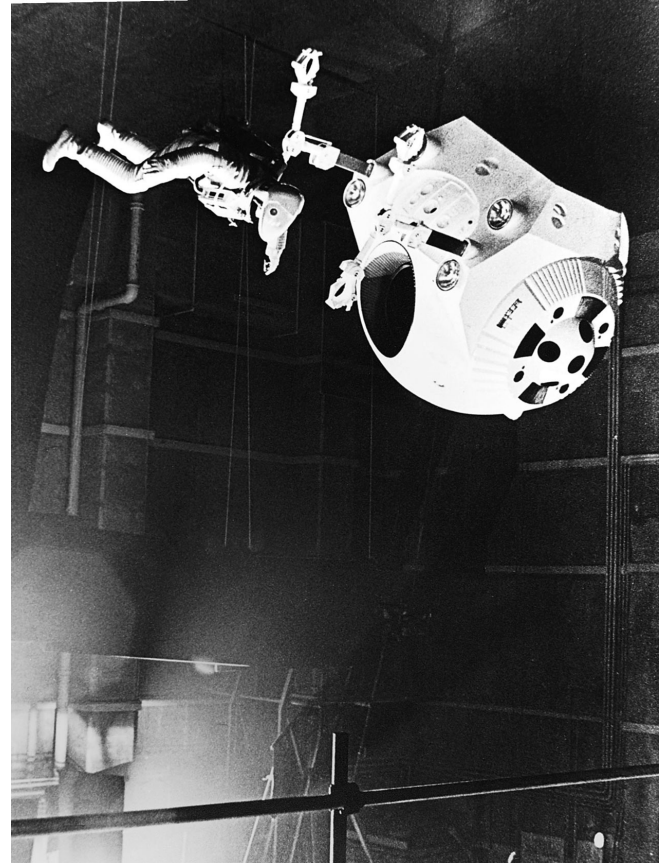
Though it was a major chore to set up, once the lights were in place, specific lighting configurations were relatively quick and easy to accomplish. "Once we had that system," explained Alcott, "it was just a matter of determining the pattern of lights for each plate. Ahead of time, we would test each plate and come up with a lighting pattern that best suited it. Then, when we were shooting with that plate, I would give the lighting plan to the gaffer and he'd just go and switch all the lights accordingly. It was easy that way. Everything was all worked out."

Rather than a light meter, Alcott utilized Polaroid pictures to judge his lighting on this and every other set- a technique he learned from Kubrick. "Before we ever started on the movie," explained Alcott, "Kubrick had models made of the sets, which he would photograph with a Polaroid- just to see an instant photograph of what was happening and how the set was going to look before he got to the point of actually constructing it. He would do the same thing when he came onto a real set. We would go onto any set and he would line the camera up, and then, just

before we were going to shoot, he'd say to me, 'Take a Polaroid'- a black-and-white Polaroid because color was no good then and it took too long to process. For Kubrick, it was insufficient to shoot a Polaroid from alongside the camera- he wanted exactly the same angle- so the camera would move out and I would move in with the Polaroid camera and take the picture, and he would look at it. I think he saw things differently that way than he did looking through the camera. When you're looking through a movie camera, you're seeing a three-dimensional image, so you're getting a feeling of depth. But when Kubrick looked at this Polaroid still, he would see an entirely different, two-dimensional picture- it was all one surface and closer to what he was going to see on the screen. And many times, just before we were going to shoot, he would change the setup because he didn't like what he'd seen in the Polaroid.

"After a while, I began to relate this notion to the lighting. I could never work with light meters, because they all rate differently. Not only that, with the Dawn of Man sequence at least, we were into a different area because we were using a natural light source- the first use of a natural light source, built right into the set- so it wasn't like the old days where you would hold a meter out and measure the foot-candles and it would give you a certain aperture. Cinematographers used to light that way, just going around and measuring the key, all the way around the set. But when you're working with natural light, it doesn't work that way. So I decided to do away with the meter and use the Polaroid, which would give me both an instant record and tell me what I was getting in the lighting." All of the Polaroids were annotated and kept on file. That way, if a shot had to be redone at some future date, a visual reference was available to help match continuity and lighting.

Not every shot in the Dawn of Man sequence required front projection. Some had no live-action elements at all and were simply static views or slow pans over vast African landscapes to establish a locale or set a mood. Since no motion picture film had been shot on location, these scenes were achieved by re-photographing the large-format transparencies on the animation stand. "To maintain a first-generation look," noted Bruce Logan, "we employed all sorts of techniques to keep from picking up contrast. One of the things we did was make contrast- reducing mattes



For the sequence in which Poole is retrieved from space, both stuntman and pod were suspended on cables from the black-velvet-draped stage ceiling as the camera filmed from below- thus concealing the support wires. To effect a sense of true weightlessness, the stuntman was suspended by a wire harness at his own center of gravity. Although the wires remained hidden only if the camera below was shooting from its specified vantage point- limiting movement and positioning - a variety of camera angles was achievable by altering the aerial orientation of the stuntman, who would be hung, alternately, from his belly or his sides, or even upside-down.

by taking the original color transparency and making a black-and-white contact of that, which gave us a negative image exactly the same size. We would develop that, then bring it back and lay it over the transparency; so wherever there was white on the transparency, there would be an added gray value, and wherever it was black on the transparency, it would be totally clear. It had the effect of totally compressing all the contrast values.”

With completion of the Dawn of Man sequence in the closing days of 1966, 2001 moved officially into postproduction— an eighteen-month period in which all of the movie’s spacecraft shots and most of the other visual effects were accomplished. During that period, Wally Veevers supervised the rigging of the models, which were lit and photographed by John Alcott on a stage draped in black velvet. “I had a lot of problems with the camera lenses during the model photography,” recalled Alcott. “They were Panavision lenses, and they were all right for making conventional films; but here was a film that needed something exceptional in depth and in quality. So I got rid of those lenses, bought Nikon lenses, and made adapters to fit onto the Panavision cameras. I can still see the first shot of the Discovery. There is blackness, and then it comes through the frame and travels all the way across. We tracked the model against black velvet to do that because we needed the depth. What made the shot perfect was a Nikon 55mm macro lens that had a working field of ten feet. I think it was the first lens working at ten feet for copying or reproducing. With that lens, stopping down at thirty-two, we could retain full depth of field.

“I always said that working with Kubrick was like going to school and getting paid for it. One of the things I learned during the model shoot was that fill is the most important part of the photography. Source lights and highlights are simple. Far more important is the fill; because if the fill isn’t right, then it will destroy the key. The key light on all those spaceship shots was something like four hundred foot-candles; and the fill was something like two and a half foot-candles. If there are two and a half foot-candles and you’re seeing it on the screen, and it’s the right density, then the fill is the real basic exposure— that’s what the camera is exposing for— and the four hundred foot-candles of the key don’t make any difference, because the fill is the predominant lighting area. So you can get away with overexposure on the source lights, but you can’t on the fill. The fill light has to be right on.”

For many of the spaceship shots, Kubrick wanted to see crew activity within the windows. “That was the thing with Kubrick,” commented Alcott. “It wasn’t enough to shoot the ship and just have a set piece visible inside— he wanted to see people moving inside there, as well. So we’d have to rewind the film and shoot a separate pass. We would blacken the whole model out and then front-project footage of people sitting at the ship’s controls onto a white card placed over the window area. In those cases, we had to plot out our camera moves frame by frame, then go back and repeat those moves manually. There were no curves. The camera moves were all pretty much straight lines.”

Another primitive form of motion control was used for views of the lunar landscape as seen through the windows of the moon bus during its flight to the monolith excavation site. “Stanley wanted the background to bob up and down a bit as the moon bus flew over the terrain,” said Bruce Logan. “The problem with the bobbing background was that we needed a starry sky above the terrain, but we couldn’t shoot it at the same time we were shooting the moon surface

because of the differential in exposure. The solution was to cut out a huge piece of wood in kind of a wavy cam shape and then set the camera on it on a long arm so it went up and over the cam like a roller coaster. It was shot very slowly- at four seconds a frame- and it took about a half day to do each take. Then the camera was brought back to the start point and the film was rewound, and the star background was shot on a separate pass. It was all strictly mechanical- no solid state involved- but it was still an early step in the direction of motion control."

The lunar landscape itself was one of several large-scale miniatures built by Trumbull and Logan to represent various backgrounds. "We never felt that matte paintings were the way to go for the backgrounds," noted Trumbull. "Stanley was very leery of matte paintings; and so was I, because it's almost impossible to achieve actual lighting effects in a painting." The principal moonscape- a forty-foot-square miniature- was fashioned out of water-soluble clay. "It was a whole side project that was like therapy for me. We had boards stretched above the set, and I'd be out there on them, hanging over this thing, building up mounds of clay and forming big craters and mountains- nothing craggy or jagged, just relatively smooth slopes. Then I'd get up in the ceiling of the stage- about forty feet up- and drop more clay and water on it, which made billions of tiny craters all over these larger surfaces. The whole thing looked really fabulous; and it was extremely close to what our astronauts ultimately saw when they got to the moon."

Unfortunately, the topographically accurate moonscape did not translate cinematically. "Kubrick wanted a jagged terrain," recalled Trumbull, "with mountain ranges and cliffs- a much more dramatic environment. Finally, after a lot of discussion, I think it was Wally Veevers who came up with the idea of making forced-perspective models. We'd build a large mountain in the foreground, and a medium-size mountain farther back, then do a tinier mountain, and then finally nothing. We'd also graduate the size of the gravel and rock and sand- everything. What we ended up with was a model that was only about three or four feet deep from foreground to horizon, and only looked good from one point of view, but it gave us a modulated surface that we could light in an interesting way, creating shadow effects that looked very realistic."

Since even forced-perspective miniatures provided minimal depth of field, numerous shots utilized composite still photo-graphs. "We'd take the model landscape," explained Trumbull, "get it all lit and everything, and then shoot several still photographs, each focused at a different point on the set. We used 4x5 black-and-white film- Polaroid PN, which is a positive-negative film- because it was finer-grained than almost any other film we could find. From there we made prints of each exposure and cut them out and stripped them together to create a composite photograph that was all in focus. Then we'd go in with dyes and put a little color back into it, and maybe get rid of a shadow we didn't want, or highlight something. Once that was done, we could combine it with other elements on the animation stand." The still technique would be used often throughout the effects production- not just for landscapes but for shots of spacecraft, as well. "We used a lot of still photographs. Every shot in the movie that is not a tracking shot with perspective shifts was done with still photographs. It was like making an animated picture."

"If you take a photo and stick it on a sheet of glass and then move the glass," stated Wally Gentleman, "in certain modes of perspective you will not be conscious of the fact that the image

isn't three-dimensional. And if you photograph your model with something like a 10x8 camera, there is no image degradation over straightforward shooting of the model because your still photography has a resolution greater than the 70mm motion picture film. Many shots of the Discovery and the Aries and the moon bus were actually animated still photographs."

In early spring of 1967, Gentleman left the production. His departure was due, in part, to a medical condition that required surgery; but another factor was his mounting frustration with Kubrick's eccentricities as a filmmaker. "My entire career I had spent doing everything meticulously and precisely," explained Gentleman, "but when I ran into Kubrick, I found a man who had an absolute obsession with the finicky details of everything; and I wasn't comfortable with that excess. After five or six years with the Film Board, I had grown into the thought of having to produce things in the most economical manner possible. On 2001, I didn't see any economies being effected at all. The budget was open, and you could do whatever you wanted, virtually; and I found this to be a rather strange circumstance because so much money was being wasted."

Gentleman also felt the work regimen was oppressive. "The hours were terrible. Every day we'd start at eight in the morning and work until eight or ten in the evening. Then, at two in the morning, there'd be a phone call: 'Hey, Wally! I've got a great idea...' That gets a bit dreary after a while. I enjoyed Kubrick The Man very much- the experience with him was vital and interesting. But I learned that one doesn't work with Kubrick- one only works for him- and I found that rather difficult. As a filmmaker, he was a little paranoid and certainly obsessive. He surrounded himself with really good people, and then proceeded to dissipate their talents. Eventually I got fed up with the sort of autocratic methods that were being applied, often seemingly arbitrarily and at variance to the useful application of the associated talent. After about a year and three months, I finally got to the point where I'd had enough and decided it wasn't worth it anymore. So I left."

With Gentleman's departure, Doug Trumbull began to take on more responsibility for the effects work, making key decisions as to which shots should be done on stage with model photography, which could best be achieved with a cutout photograph on the animation stand, and which should be relegated to the 'Sausage Factory,' an oversize horizontally-oriented animation setup consisting of a fifteen-foot pane of glass mounted on sliding rollers in front of a camera. "We called it the 'Sausage Factory' because the plan was to knock out twenty shots a day with it," recalled Trumbull, "which, of course, never happened. It was more like one shot every two days." Nevertheless, a great many of the film's spacecraft shots- those requiring little or no change in perspective- were produced wholly or in part on the makeshift device. Wally Veevers, who had designed and supervised construction of the Sausage Factory, also oversaw most of the work produced on it. "We could mount photographs of the moon bus or a spacecraft to it, and then add rear-projected live-action footage into the window areas, and make it all move against a background of stars, or whatever. It was a crude but effective means of repeating movements, in that there was one master motor that drove the rig through a series of gear boxes connected to selsyn drive motors. There would be a selsyn drive motor on the sliding glass panel where we mounted the model photograph, and another on the sliding star background, and others on the camera dolly track and on the pan and tilt of the camera. All

these movements would be interlocked so we could do a number of passes and get them all to register perfectly. The major drawback with the Sausage Factory was that all of the moves had to be continuous. There was no way to vary the speed of any one portion of the move. For example, we couldn't have the camera decelerating to a stop while the spacecraft continued to glide through the frame, or something like that, which is a capability we really could have used. But there were no electronic systems. All we had were simple mechanical systems- and I think we did as well as we could with the technology available at the time."

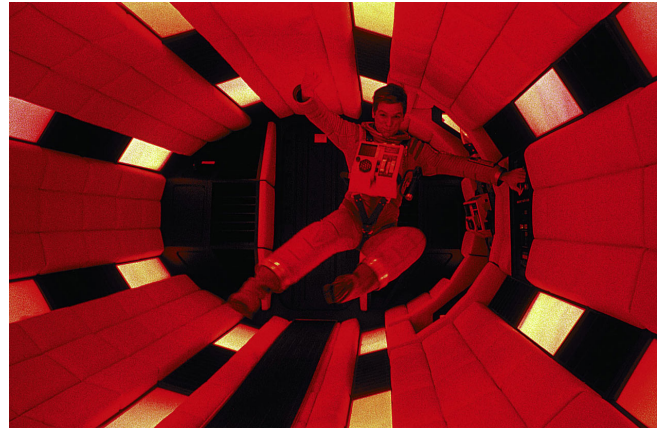
With the arrival of the Oxberry animation stand, which would replace the jury-rigged stand used earlier in production, a main animation unit was formed under animation supervisor Colin Cantwell- another Graphic Films alumnus. For the better part of a year, around-the-clock animation shifts were manned by Bruce Logan and recent arrivals Zoran Perisic and Richard Yuricich. "Almost everything was done single-frame on rather conventional equipment," explained Logan. "There was no motion control, as such, except for that achieved through the use of mechanical devices and cams. The animation unit was shooting on a single-column Oxberry animation stand- fabricated in England- with a conventional X-Y, with a double rotation. In other words, the main table rotated, and the gimbal it was sitting on also rotated, which allowed us to do compound moves and diagonal paths without feeding in X-Y numbers to achieve the same result."

Much of the animation workload entailed adding starfields to shots of ships in space. The original plan had been to generate starfields practically by drilling holes into sheets of metal and backlighting them. To this end, a considerable amount of testing had taken place early on. "The holes varied in size down to about a sixty-fourth of an inch in diameter and took forever to drill," recalled Wally Gentleman. "But once they were done, the idea was to backlight them and position them behind the models, or use them on the stages outside the spacecraft windows and whatnot. One of the problems with that approach was that as the camera tracked by, the holes became elliptical with relation to the lens, and the light intensity changed and the stars either faded out or twinkled, depending on the situation. An even bigger problem, though, was the fact that when we got stars that looked just right on 70mm, they'd totally disappear when we reduced them down to 35mm. The grains in the emulsion would coagulate, and what was a beautiful, delicate star-field would just disappear. With the drilled metal starfields, it was very difficult to make the kind of fine adjustments needed to correct the problem. An idea that Kubrick had as an alternative was to take a sheet of glass, put paint drops on it, and set it at 45 degrees behind the model. By underlighting it, we'd get brilliant spots of light. However, since the glass was at an angle to the camera, and because glass has two sides to it, we ended up with a double image for every spot. Finally, we came around to deciding that the only way we could possibly do stars with any distinction was optically, on the animation stand."

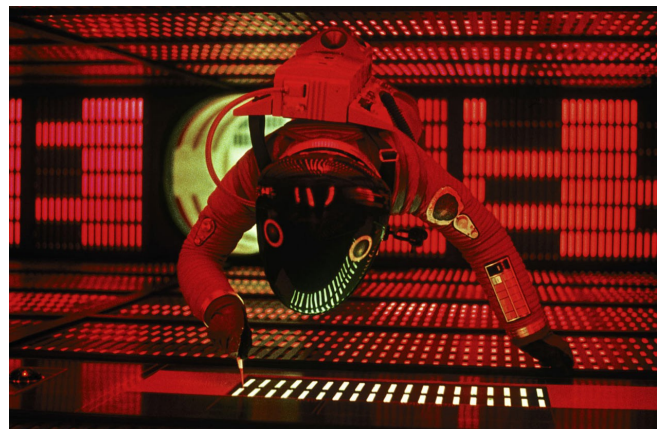
Most of the starfields were produced by Trumbull. "Douglas would take an airbrush- he's a master airbrush artist- and he would turn it down to where the pressure was maybe a couple of pounds, to where if you just pumped the rod, it would spit out paint," explained Richard Yuricich. "He would take this black paper, stretch it and glue it to a piece of board; and he would just sit there and squirt out these stars. In a matter of seconds it would be done- 'There it is, boys!'- and it would be a terrific star background. The backgrounds would then be photographed on the animation stand using top lights. The top lights would be polarized at 45 degrees to the artwork and light would go on the film through the polarized lens, so any glare would be erased. We would lose a stop and a half in the process, so the blacks really went black and the whites stayed clean. Dust was always an issue, but we got pretty good at seeing it falling- the camera would be shooting and we'd just kind of blow it off before it hit the artwork. Some of those star backgrounds took eight, ten, twelve hours to shoot.

"Some scenes required static stars, but more often than not- if the camera was moving or a spaceship was moving, or if we wanted to make it look as if it were moving- it was done by moving the stars. Star directions and speeds were, for the most part, figured out by Con Pederson. The moves were very small- maybe five thousandths of an inch or less- and they were all done by hand. The Oxberry stand came with hundredth-of-an-inch mechanical counters already included, and we could take those hundredths of an inch and break them down into thousandths by just taking pieces of tape and dividing the amount of move with little markers and then getting a clear index with a pointer and moving things along like that. I think the exposures were usually four seconds per frame."

To optically combine the starfields with still or model spacecraft footage, rotoscope mattes were required to prevent the stars from bleeding into the ship imagery. Since there was no matte pass involved in the photographic process, each frame of film requiring a star background had



When HAL refuses to open the pod bay door to readmit Bowman, the commander enters through an airlock, aligning the pod hatch to the airlock door manually, then triggering explosive bolts to send him shooting through the airless corridor. To shoot the scene, Keir Dullea was suspended by wires at the open top of a vertically-built corridor, then alternately lifted and lowered within the shaft as the upturned camera at the bottom captured the action. When the image was laid on its side, and the film was speeded up, it looked as though the astronaut was being blasted back and forth through the airlock.

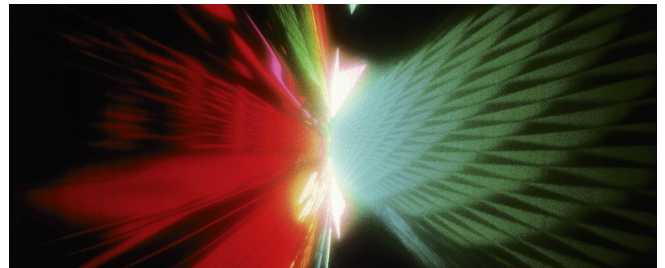


Bowman gains access to the HAL 9000 brain compartment and begins to deactivate all of the rogue computer's cognitive functions, save those that automatically maintain the ship's navigational and life-support systems. Dullea was suspended in a three-story-tall set, which was built and oriented vertically, but shot horizontally to suggest a weightless environment.

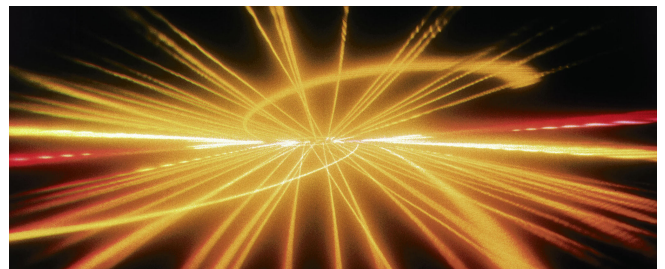
to be meticulously hand-rototoed by a team of twelve to sixteen artists who were given the tedious task of tracing projected spacecraft images onto animation cels and then blacking them in with ink. "This was done in what was known as the 'blobbing room,'" said Colin Cantwell. "The rotoscopers were in there in the dark all the time- just them and some work benches and rows of still projectors- and the most exciting thing they ever got to do was paint blobs of black paint. This was an effort of months and years, and so they were gradually going kind of bananas. Any time the rest of us got bored or began to think our jobs were mundane, a perfect cure was to go over to the blobbing room and talk to the blobbers. They were always so glad to see somebody- anybody. All of them became great friends during the production- I'm sure as a means of survival, just to be able to do that for that length of time. Most of them went from the finish of 2001 over to working on Yellow Submarine- and they were so happy not only to work in the light and look out the window, but also to paint in colors. It was a reward for all they'd been through."

After all the frames in a given shot were rotoscoped, the inked silhouettes went to the animation unit. "There were just reams and reams of these cels that had to be photographed," recalled Bruce Logan. "We shot each of them in sequence on the animation stand, and the resulting film was then processed and used as a holdout matte during the optical stage, so the ships and stars could be combined."

Many shots were done on original negative. "We did a lot of held takes," continued Logan. "The crew on stage would shoot, for example, a spaceship five or six times, and each shot would have a head sync mark on it. Then they would stick it in a can - but it would not be sent to the lab for processing. Instead, it would go to one of the optical printers where another element, such as stars, would be added to the shot by running the original unprocessed negative with a moving star background and a holdout matte for the ship. Sometimes, it would also go to the animation camera room. It was a hairy process overall, because of the number of things that could go wrong and the number of different hands the negative had to go through. Just physically passing through the cameras could scratch the emulsion. That's why we always had several takes in the can; if something went wrong with one take, we could go to the next one. It got pretty nerve-wracking



As the Discovery nears Jupiter, Bowman ventures out in a pod to investigate the appearance of an enormous monolith floating in space. Through the Stargate corridor, which mysteriously appears, the lone astronaut enters an alternate dimension replete with luminous, otherworldly sights. Although a number of physical and visual effects techniques were tested as a means of creating imagery for the sequence, most of the shots were achieved through an innovative form of streak photography developed by Doug Trumbull. Slitscan- as the process was called- essentially entailed moving an open-shuttered camera toward shifting light and artwork positioned behind a slot, thereby producing streaming planes of light in accumulated exposures.



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when a shot had gone wrong maybe five or six times and we were down to our last original take in the can. If that one went wrong, the stage crew would have to go back and reshoot. Stanley was a real perfectionist about everything, so no mistakes got by."

Though much of the animation was mundane and lacked the sex appeal of flashier model shots, it was nonetheless the backbone of the effects assignment. "The amount of work we did was incredible," remarked Logan. "For months on end, we had three shifts going round the clock, just shooting mattes and star backgrounds. We shot more than two thousand slates on the animation stand. By the end of the film, though, we had produced so many star backgrounds that we no longer had to shoot specific ones for each and every shot- we could just go into our existing library. Con Pederson had this shot planning board with all the elements needed for each shot, and he was largely responsible for selecting the backgrounds. In dailies, we would simultaneously project two pieces of film, one being a shot of the ship against black and the other being a star background that Con thought would probably have the right speed. By overlapping the two images, we could see if the shot worked and if the illusion of movement was correct. Sometimes the angle would be a little bit off or the stars would run a little bit fast, so we'd either pick another background from our library or we'd shoot one specifically for the shot. Then that would go to optical for final compositing."

Some shots were produced entirely on the animation stand, without going through the optical printer at all. Among the most prominent was the movie's dramatic opening- dubbed the 'occultation shot'- in which the camera booms up past the moon to reveal the earth and, behind it, the far distant sun. "The idea for that shot came from the storyboard planning department," recalled Logan, "which was mainly Con and Doug and Stanley at that point. About halfway through the production it was decided to do a shot of that nature. I don't think it was going to be the main title shot, originally, but it was going to be early in the movie. We shot it maybe four or five times, it was approved, and we went on to other things. About a year or so later, Stanley decided to make it the main title shot. He wanted it turned upside-down, however - with the moon at the bottom of the frame instead of the top- so we scrapped what we'd done before and started over."

The moon was represented by a black-and-white still photograph, which was cut out and filmed toplit on the animation stand in a single pass. "The photo was mounted on glass," said Logan, "with a piece of black paper beneath it, and it was made to slide down out of frame to simulate the pan. Then, since this was all original negative- no dupe generations- the film was wound back and the earth was shot backlit. At the time we were making this movie, there were no photographs of earth from space, so we used a transparency shot from a model. The moon photo stayed in place and became a matte for the backlit earth pass. The top lights were turned out- to keep from rephoto-graphing the moon- and the earth transparency was revealed as we panned the moon artwork down. The sun was just a cut-out with an extremely intense backlight

replete with luminous, otherworldly sights. Although a number of physical and visual effects techniques were tested as a means of creating imagery for the sequence, most of the shots were achieved through an innovative form of streak photography developed by Doug Trumbull. Slitscan- as the process was called- essentially entailed moving an open-shuttered camera toward shifting light and artwork positioned behind a slot, thereby producing streaming planes of light in accumulated exposures.

behind it. I had a piece of black paper that was precisely the same size as the earth image, and I very carefully had to transfer that down onto the glass. Then we ran the film back again and revealed the sun from behind this black piece of paper, which was now the matte of the earth. For the sun cutout, we started by using a piece of paper, but the heat from the light was so intense that the paper would start to curl and the earth matte sitting over the sun would start to curl, and matte lines would suddenly appear. To help deflect the heat, we then cut the sun out of a sheet of aluminum, which worked pretty well. Once we got the sun, we went back and ran all of those moves again and put the stars in. Then we rewound the film a final time to add the titles. It was a difficult animation shot- about 1440 frames- and I remember all five passes of every frame. Stanley insisted that it be perfect, and we did it about ten times before we got it just right." Even then, however, the shot refused to just go away. "It was the main title shot- all first-generation- and Stanley loved it so much that he did not want any dupe generations for the foreign versions of his film, either. So my very last project on the movie was to shoot the occultation shot six more times to get six different foreign language versions. That shot was my own personal hell- I had to keep doing it again and again and again."

The effects unit would also devote considerable time to realizing a story element- gleaned from Clarke's original treatment- in which the Discovery is drawn to one of the moons of Jupiter due to a strange perturbation in its orbit. "When you looked at it one time," explained Trumbull, "the moon would seem to be large; and when you looked at it another time, it would seem to be small. So the characters reasoned that maybe this moon was not round- maybe it was oblong, or some strange rectilinear shape that changed its apparent dimensions as it rotated. As it turns out, however, they find just an ordinary-type moon; but when they get closer, they discover a slot in it- a huge rectangular hole, approximately the same proportions as the monolith, with sheer, perfectly flat sides. In this version of the story, Bowman and Poole would head out in space pods to look down into the slot; and way off at the other end they would see stars, but not the ones they ought to be seeing. The slot is like a gate into another galaxy. So they drop probes down inside it- little measuring devices that accelerate and disappear. Finally, one guy gets sucked down through the slot, and the other one goes chasing after him."

Though the entire story point would be dropped, attempts to visualize the interior of this slot led to the conceptualization of the climactic Stargate sequence, which relied heavily on visuals created through an innovative technique called 'slitscan.' "Slitscan evolved only after some physical effects had been tested- spinning mirrors and such, which were a disaster," explained Trumbull. "As a simple explanation of how slitscan works, I think everyone, at one time or another, has seen a time-exposure photograph of city streets at night, where you see nothing except white and red streaks of light caused by the fact that cars are moving while the shutter is open. You do not see the cars at any one point; instead, you see an accumulated exposure of cars. If, during that same photograph, all the cars were blinking their lights on and off rapidly, instead of having them continuously on, you would get a series of dots and dashes. If you expanded that and took not just a point of light, but a bar of light- a fluorescent tube, for instance- and moved that toward the camera while the shutter was open, you would create a plane of exposure rather than a line. Then, by modulating that light- turning it on or off or

changing patterns in front of it- you would create an accumulated exposure that could be fairly complicated in content.”

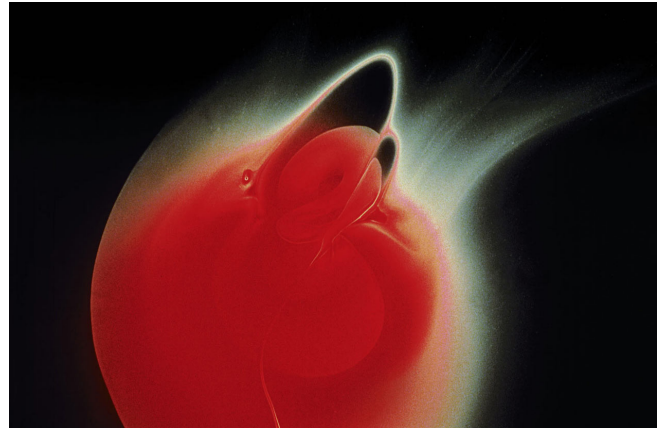
While many have sought to lay claim to the slitscan process- a visual effects phenomenon that would permeate film and television graphics in the aftermath of 2001- the most compelling evidence as to its origin resides in a bit of experimental animation produced by avant-garde filmmaker John Whitney, Sr. In the early sixties, Whitney- who would later pioneer in the usage of computers to create film imagery- concocted a piece of cinematic op art by photographing backlit graphic artwork passing behind a narrow slit as the slit itself moved through the frame. While still at Graphic Films, Con Pederson had presented this footage to Kubrick as something that might have potential use in 2001. Evidently, its applicability was not apparent at the time, however, because nothing came of the idea for nearly two years, until Doug Trumbull, grasping for a means to initiate the Stargate passage, remembered Pederson having spoken about the Whitney material. After pondering the possibilities, Trumbull decided to take the slitscan notion a step further by applying a third element, that of the camera moving toward the slit- which elevated the effect from a two-dimensional novelty to a three-dimensional jaw-dropper.

When early tests of the technique, produced by Trumbull on the animation stand, suggested its tremendous visual potential, Kubrick authorized the construction of a dedicated slitscan machine in an upstairs room of the animation building. The essence of the device- essentially a horizontal animation stand on steroids- was a six-foot-tall rotatable slit cut into a sheet of metal and positioned directly in front of a mechanized twelve-foot-long glass panel onto which backlit artwork was affixed. “The room was painted totally black,” recalled Trumbull. “We erected our slit with a light source directly behind it. Then we built a track leading up to the slit and mounted a 65mm camera on it with a shutter that could stay open on one frame of film. To modulate the lighting coming through the slit, we used high-contrast negative transparencies that would slide behind the slit as the camera moved toward it. Some of them were very tightly controlled patterns that we photographed from books of optical art- elaborate patterns of circular lines or straight lines, bars or grids or whatever. A lot of junk from HAL’s readouts ended up in there. Then we’d lay in different colors with gels. So, by having this artwork move behind the slit, backlit, we were able to effectively turn light on and off. As we did that, we moved the camera along fourteen feet of track toward the slit- a full fourteen feet for each exposure. It took about forty-five seconds to a minute per exposure, and each frame was made up of two exposures.”

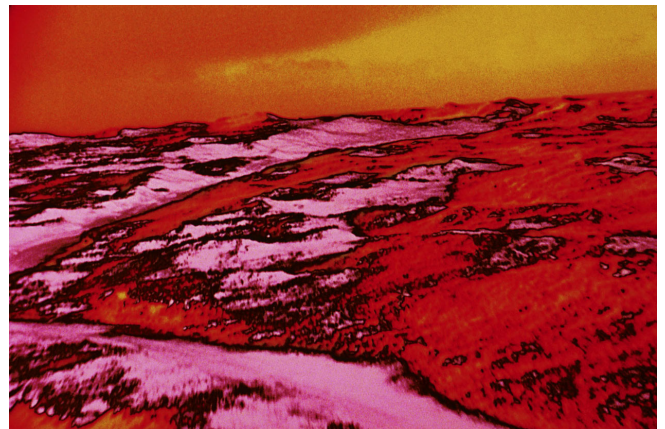
The relationship between the camera and artwork remained constant on each pass- except for an incremental shift that made the apparent point in space where the artwork fell during the exposure change slightly on successive frames, thereby creating the feeling that the spectator was moving along it. “While the camera was moving forward,” explained Trumbull, “it was changing focus all the time and remaining focused on that slit. So, in essence, we created a photographic image that was in focus from fourteen feet to one inch, which is theoretically impossible. As a result, though, we attained infinite depth of field, which was one of the things that created the illusion that this stuff was tremendously large- there was no fall-off of focus, which would have given it away in a minute.”

Once it was set up, the slitscan machine ran itself for hours at a time, requiring only that Trumbull or Zoran Perisic- who worked with him on the shots- be present to keep an eye out for possible malfunctions. "The camera was a big, heavy device that traveled along this track pretty fast," Trumbull elaborated, "until it got about two inches from this giant twelve-foot pane of glass and had to stop dead. It had a special electric brake and clutch and a method for reversing all the motors, and it ran automatically. There was always a certain amount of wear during a shot, though; and after a while, the brake would start to slip, and the whole thing would slide a little bit closer to the glass each time. So if someone wasn't there to make the necessary adjustments, sooner or later it would go crashing through the glass. But it was basically automatic; and oftentimes that camera would run for thirty-six hours, continuously, to shoot one take. All together, we spent at least six months working on the slitscan footage."

Though the footage was impressive, Kubrick began to have doubts about the slotted moon. "Somehow it just never looked convincing," allowed Trumbull, "but we kept plugging away at this slitscan material, cranking out thousands and thousands of feet of different patterns and textures and speeds and orientations." It came as no surprise when the slotted moon concept was dropped. In its place was a scene in which Bowman- sighting a monolith of massive proportions drifting in space near Jupiter- leaves the Discovery to check it out. "The idea was that Bowman would go out in his pod to investigate the monolith, which is now enormous- like three hundred yards long- with a black mirror surface. Bowman was to take the pod up to the surface of this block, and, like the apes had done, reach out to touch it with the arms of the pod. But he finds out there's not really any surface there at all, and just slips into it. To depict that, we worked out a shot where he and his pod approach a mirror image of the same thing, then just cross and disappear into the black surface. The pod Bowman was in was one of the full-scale versions, mounted on tracks and photographed from carefully planned camera angles. We'd have the pod move, say, right to left and away from the camera in one shot; then we'd rotate around to the other side and have the pod move left to right and toward the camera. Then we'd



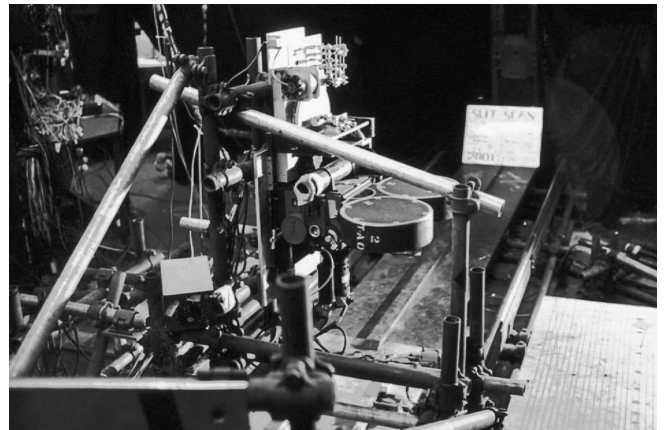
Within the Stargate, Bowman witnesses a series of cosmic explosions, realized by filming combinations of colored paints being dropped into a table-sized tin of black ink and banana oil. Shot at high-speed and in reverse, the dispersement of the pigments in the oil resulted in strangely beautiful slow-motion images that seemed to drift toward camera.



Bizarre alien landscapes were suggested by manipulating and mismatching the color registers of aerial location plates photographed in the American Southwest and the Scottish Hebrides.

optically combine the two in conjunction with a shot of the monolith. That was going to be the beginning of the Stargate sequence– but it was not a great success. We filmed it and did a lot of opticals for it, but the merging of the mirror images never looked right.”

A successful alternative arose as a result of work being done on the animation stand for the Jupiter approach shot. “Stanley could never fully visualize whether he would like a shot or not unless he saw it on the screen,” stated Trumbull, “so we would take still photographs of Jupiter and several moons and some stars, put them in some kind of configuration, and just shoot thirty feet of film so Stanley could look at it in the theater. Well, one of the configurations that Colin Cantwell came up with was to have Jupiter in the bottom of the frame and all these moons lined up in a vertical row above it. It looked terrific– everybody liked it enormously. It was like a major religious alignment of moons. Then someone suggested that we put the monolith up in there, so we did. Suddenly the whole scene started to come together out of these random elements.”



Excited by the early slitscan tests Trumbull was doing on an animation stand, Kubrick authorized the building of a dedicated slitscan machine. The oversize device– akin to a horizontally-configured animation stand– consisted primarily of a six-foot-tall, rotating slit cut into a sheet of metal and positioned in front of a mechanized, twelve-foot-long panel of glass on which backlit artwork was affixed. For each single-frame exposure, a motorized 65mm camera traversed a fourteen-foot-long track leading up to the slit, which remained always in focus. Incremental changes in the art from frame to frame created a vertiginous sense of movement. Two full exposures were required for each completed film frame.

“Only one element in that shot was not animated,” observed Cantwell, “and that was true of most of the shots in that particular sequence. Views of the monolith rotating and moving about were done using a six-foot-long miniature- six-feet-long passed for a miniature on 2001- that was lit and shot on a stage with a motor revolving it like a barbecue spit. The black block was filmed against black- positioned to fit a particular location on the screen- and added into the space shot. The moons in that shot were generated with a slide projector and a small sphere about a foot in diameter. Some colored patterns and textures were loaded into the slide projector, then projected across that sphere, which was photographed with a 35mm still camera. We could shoot the moons full-phase, or half- or crescent, just by changing the position of the slide projector. And sizes could be varied simply by setting the camera closer or farther away from the sphere. In the end, we had this nice set of 35mm slides with little moon images on them that ranged from about a quarter of an inch for a large moon down to an extremely small image for a small one. For the big alignment shot, we literally just cut little round holds in black paper and then rephotographed the slides bottom-lit.”

“We had a technique we used all the time,” noted Trumbull, “of putting two pieces of film on separate projectors and projecting them onto the screen at once. That way we could see a spaceship with a star background, or any other combination of elements. We tried this using the slitscan material coming out of nowhere- right out of the stars- and it looked terrific. I had filmed one slitscan shot in particular that was different from all the others in that it started from total black. Then points of light coned out of the black, revealing more and more density of artwork, and at the same time accelerating since I had used a little accelerator motor to make the effect keep going faster and faster. That worked especially well for this scene. Thus, for the final shot, we filmed this religious assemblage of moons and Jupiter, added the monolith, built into it a vertical pan to get up and away from that, and then let this slitscan stuff come out of the sky. So it was essentially the outgrowth of a lot of different ideas coming together that gave us a mechanism for getting Bowman started on the trip.”

Though six months of cranking out slitscan footage carried with it a measure of tedium for Trumbull, the young effects artist was, overall, excited by the potential of the process. “I was very aware that the concept was much broader than what we were doing for 2001,” stated Trumbull, “and that we could virtually create anything in space through some form of accumulated streak exposure. So I started experimenting with other applications of the technique. One thing I did was to make a wooden drum, about six feet long and one foot in diameter, and cover it with crinkled aluminized mylar. Then I placed a little piece of black paper



Throughout the four-year production, Kubrick explored numerous means of creating an extraterrestrial being for Bowman to encounter at the end of the film. Approaches involving optically distorted humans in makeup, video feedback, kaleidoscopic projections, sculpted light and optical illusions were all tested and rejected before Kubrick made the decision to leave his aliens enigmatic and physically unrevealed.

at an angle in front of the slit so the camera could only see the reflection from the slit on the lumpy surface of the drum. So now, instead of a flat plane of light, I had one that was randomly modulated; and by shooting the drum horizontally, I created something that looked like a rolling sea of light, changing color and shape as it came toward the camera. It was used in the film- it's one of the last shots in the Stargate sequence before you go into the explosions- but it's so underexposed that it's hard to tell what it is. I also did a number of other tests, which Stanley just rejected out of hand, that I thought could have been built into that end sequence quite successfully; but if Stanley didn't come up with an idea himself, he would automatically reject it."

Trumbull employed a variation of the adaptable streak photography technique to generate Jupiter. "Jupiter was done with a semicircular band that could rotate on a special rig," related Trumbull. "Onto that band, two projectors projected a revolving transparency of some artwork I had painted; and the result was a spherical scan, rather than a linear scan, because the band just rotated on its own axis rather than moving through space. So Jupiter was just shot as a still photograph. I used an 8x10 camera- at f/124- and it took about two hours to make one image. Once we had that, we could composite it with moons and stars and such on the animation stand."

At one point in the Stargate sequence, a series of cosmic explosions sweep across the void. "That was a crazy setup," stated John Alcott. "We had a big black tin, about the size of a table, filled with black ink and banana oil. It had a hell of a smell to it- it could really make you ill. We photographed that with a very close lens. We had so much light coming in onto it, and the intensity was so great that we had to shoot it quickly because the radiant heat would boil the ink. We would take a matchstick or a toothpick and dip it into this white paint and let it drop into the center of the tin. It was like dropping paint into thinners- as you dropped it into the black ink, it would shoot off into different areas. We photographed this at high speed, at 96 frames per second, in reverse, so that instead of its dispersing away from camera, it would look as if it were coming toward camera. It was simple, but very effective because you could put a white spot and then a little red on top of the white and get a buildup of different colors."

The Stargate sequence also featured alien landscapes, concepts for which Wally Gentleman had discussed with Kubrick at the start of the prep period, when the director was still in New York. "The off-key, unworldly landscapes were an outgrowth of our decision to use color separation masters in order to get the ultimate in quality color reproduction," explained Gentleman. "With this process, you start with your original color negative, and then, using narrow-cut filters, separate out the red, the blue and the green to obtain three black-and-white separation positives on motion picture film. The red filter will admit only the red color within the scene; the blue filter will admit only the blue; and the green the green. Then you print each strip back in register through the appropriate filters in order to get your final composite. The process is expensive and time-consuming, and when you're doing special effects work it triples the number of elements in a given shot; but the advantage is that you can balance each of the colors separately without affecting the others. I had done a lot of my early work in the industry with the three-strip Technicolor camera- which did basically the same thing- and had learned that by switching either the filters or the masters, you bastardize the whole system and can get

a really weird effect. So I put this up to Kubrick as a means of introducing color swings that would falsify anything he would shoot on earth, and he decided to incorporate it into Bowman's trip." Aerial footage for the landscapes was captured by second unit director Bob Gaffney, who flew perilously low over spectacular geological formations in Monument Valley and northern Arizona to obtain the desired imagery. Additional footage for the scene was shot in the Hebrides in Scotland.

Among the surrealistic environments created for the Stargate sequence- dropped from the final cut of the movie- was the 'City of Lights,' another Trumbull innovation. "That went back to the point-of-light idea," observed Trumbull. "I made a series of panels with hundreds of light bulbs all over them in patterns- hexagonal patterns, rectangular patterns, circular patterns- in varying diameters. For example, there would be a rectangle inside a rectangle inside a rectangle, and each could be turned on and off independently. Then I rigged up a thing that allowed me to turn the camera up on its side; so now, instead of moving in and out toward a piece of light, it was moving relatively up and down. With this configuration, I could shoot the pieces of artwork- these panels of light that I could switch on and off during the exposure- and what I would get would be volumetric scanned exposures of building-like shapes. I made a bunch of cam-operated sequencers that would change the diameter of the shapes as they scanned vertically in space so the shapes would taper off as they got taller, like The Empire State Building. In fact, the whole thing looked a bit like the New York skyline, only it was all pure light and all transparent. Then, while the buildings were being scanned vertically, I introduced another camera motion where the camera was also moving toward them and over them at the same time. It was going to be a fantastic effect; but it just didn't fit into the movie, I guess."

Kubrick rethought and revised no aspect of his movie more than the matter of Bowman's actual contact with the aliens. In his early drafts, Arthur Clarke had included such an encounter; and from the opening days of preproduction, Kubrick had commissioned hundreds of alien concepts from a variety of sources. "In one treatment," related Gentleman, "the alien was to come along and take Bowman by the hand. It was going to be a towering insect-like creature- rather light and vaporous. One logical way to do this would have been to shoot the creature with a variable anamorphic lens to elongate the image onto film. With such a lens, you can squeeze the image from side to side and from top to bottom, and you can increase or decrease the ratio of the squeeze. Then, by projecting that squeezed image onto a mirror positioned in front of Bowman at an angle 45 degrees to the camera, we could have made the alien appear to be standing right next to him, and it would all have been on the original negative. Quite traditional, really- the technique goes back to the stage arts.

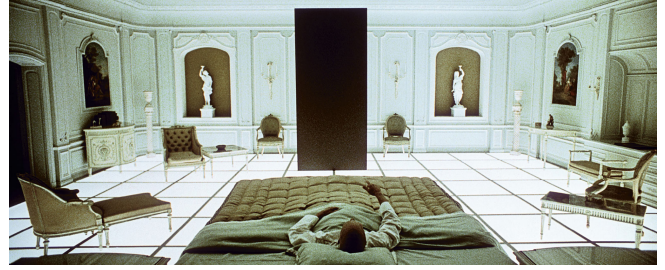


Having survived the harrowing Stargate passage, Bowman finds himself in a room resembling a hotel suite- an incongruous, but familiar-looking environment created by the aliens to put their guest at ease. Over an unspecified period of time, Bowman undergoes several significant age transitions. For all of the aging stages, varying only in degree, Stuart Freeborn applied layers of liquid latex to hand-stretched areas of Keir Dullea's skin, forming wrinkles when the skin was released.



Acting upon Kubrick's instructions to make the actor look as if he were 120 years old in the last stage of the age progression, Freeborn employed a bald cap featuring protruding veins, latex appliance eye bags and neck pieces, and numerous coats of latex wrinkles.

"There were many other alien concepts- most of them created after I left. One was a cone-shaped thing with pea bulbs all over it- a tall mass of glittering light that looked like a Christmas tree. Kubrick had Doug Trumbull working on the thing, but Doug was rather contemptuous of the whole idea. Doug would always state just exactly what he was thinking- about everything- which I think nettled Stanley in the beginning, but he gradually got used to it. Doug was, after all, dealing from a position of authority since his work was so very good, from concept to execution."



As the much-aged astronaut lies dying, the monolith appears at the foot of his bed. Though not clearly evident in the film, the alien-fabricated room set boasted a number of unusual characteristics, such as walls without windows or doors and a floor made up of self-illuminated panels.

"We spent an enormous amount of time trying to design extraterrestrials that we could include in the film," affirmed Trumbull. "I produced quite a few alien effects using video feedback. Video feedback has a strange kind of lifelike quality to it, so I made a video feedback system for creating totally nonhumanoid shapes of pulsating light. I also created some aliens using the same concept as the City of Light, only rather than having a lot of little light bulbs, I put together a kaleidoscope projector that produced varying-diameter shapes, and then multiplied those into four facets and projected them onto a piece of white cardboard. As this thing moved in space, it would create a light image of variable volume that would be somewhat humanoid in shape. By changing the patterns in the kaleidoscope from a small diameter to a sudden larger diameter, and then tapering down and going into two thinner diameters, I could roughly create the shape of a head, shoulders, arms, body and legs. Yet it was all just volumetric light that looked sort of like a jellyfish- transparent luminosity. There were things about it that worked and things about it that didn't- such as, it was very difficult to get these light characters to move or articulate. It just got to be terribly complex."

Brian Johnson was also involved in developing a number of alien concepts, which, like all of the others, would never reach fruition. "Stanley wanted something that was really different, but didn't know just what," commented Johnson. "At one point he wanted something like a Giacometti sculpture- humanoid in shape, but very thin and distorted. So I got involved in producing a suit of light with about five thousand tiny bulbs wired onto it. The idea was to put one of the dancers we had choreographing the ape sequence into this suit- which was made out of black velvet- and then photograph him with star filters on the lens and various other things. The lights alone would define the creature. Then we were going to try to squeeze the image in some way and distort it so that we'd have this weird creature that would float about. I worked on that for quite some time. We also went through a variation of that idea, utilizing a black velvet suit with a whole series of front-projection dots that we projected images onto. The thinking was that, without thousands of pea bulbs wired onto his suit, the dancer would have much greater flexibility of motion. But all this was near the end of production, and it never got cut in. I don't think it was quite what Stanley wanted."

Not all of the alien concepts involved optical effects. Stuart Freeborn was also drawn into the fray. "Stanley came up to me one day," recalled Freeborn, "and he said: 'I've got an idea. What

if we do a kind of optical illusion?’ He had seen a dotted pattern somewhere, in front of a dotted-pattern background– and the result was something that was virtually invisible, yet somewhat visible just because it was on a different plane than the background. It was an intriguing idea, and Stanley asked me to begin working on something along those lines. So we got a performer, and I made a white bald cap that fit him nice and tight; then I put black round spots evenly all over it. I did the same thing on a pair of tights that covered the rest of his body. We got the largest paper hole-puncher we could locate, and stamped out perfect rounds of black paper, which we glued all over his white form. We covered him completely– right over his feet, all down his legs, everywhere. Then we stood him against a white background with the same-size black dots all over it. The effect was stunning. Standing still, he would disappear into the backing; but when he moved, you could just make out a shape. It was an amazingly weird effect– quite extraordinary– but I don’t think it really fit in the movie. I could never see how Stanley was going to use it– and, of course, he never did.”

In the finished film, Bowman does not meet the aliens face to face. Instead, he finds himself– alone– in a stylized, but still familiar-looking room. “The aliens realized that if they brought a human out to wherever it was they happened to be, and then showed him what they looked like and how they lived, it would probably drive him mad,” explained Tony Masters. “That was the rationale anyway. So the aliens created an environment for him, out of his own memory, that he would recognize and feel at ease in. It was supposed to be like a very posh hotel suite. The odd thing was that it would have no windows or doors, and it would have this strange illuminated floor. You never see behind the camera, so it isn’t that apparent on the screen; but, in fact, the set had no windows or doors in it– there was no way in and no way out. It was built something like twelve feet up from the stage, and the floor was made up of three-foot squares of perspex– each one with a 5K lamp underneath it. I’ve never seen so many lamps. It was like an oven in there.”

A number of interesting– as well as potentially illuminating– props wound up not being featured in the sequence. Bowman was to discover a telephone, for example, and attempt to pick it up– only to find that the handset would not lift from the cradle. “He also was to find a phone book dated June 2001,” recalled Trumbull, “which looked like a Bell System directory, with the moon and the earth in sort of a double eclipse on the cover. But when he opened it up, there were no phone numbers inside– because, obviously, Bowman doesn’t know the phone numbers, and everything in this environment supposedly has come out of his own memory. There was a Gideon Bible– all of the pages blank– and a lot of other paraphernalia based on fragmentary things he didn’t know in complete detail. So, originally, there was going to be a lot more information as to what the room was and where it had come from.”

Shot, but then excised, were other connective moments. “For example,” explained Trumbull, “Bowman walks into the bathroom in his spacesuit, pokes around in there, and sees himself in the mirror. By the time he comes back out, the pod– which had been sitting in the room– is gone; but on the bed is the housecoat that he ends up



wearing in the next scene. He goes over to the bed and sort of picks up the coat and feels it, then sees a pair of slippers on the floor- it's as if people are coming and going while he's there. But Stanley dropped all of that out, and instead went with these overlapping, interconnective time jumps, which could occur in a split second or over thousands of years- who knows?"

Still in the mysterious room, Bowman- now aged and infirm, courtesy of a makeup transformation by Stuart Freeborn- lies on his deathbed. At the foot of the bed, the monolith stands before him. A diaphanous form materializes, and the film cuts abruptly to a point in space- miles above the earth- through which drifts a human fetus enclosed in a luminous sac. Once again, the monolith has worked its magic. Bowman has been reborn as the Starchild- the next quantum step in human Evolution- and is being returned home to fulfill his destiny.

Inspiration for the Starchild came from a pioneering series of intrauterine photographs, by Lennart Nilsson, revealing human fetal development from conception to birth. "Stanley didn't want the Starchild to look like a normal human baby," stated Johnson. "He wanted it to have a more evolved look, with a slightly bigger head. An artist named Liz Moore sculpted it. Originally it was going to be much more complex, mechanically, with arms and fingers that moved; but then Stanley had the idea of surrounding it in a cocoon of light, and in the end decided that all he really wanted was for its eyes to move. The eyes were made of glass, and I built a little mechanism using drives and bearings and some selsyn motors that made them move sideways and slightly up and down."

Kubrick worked out the photographic technique used for the Starchild. "He shot it through about fifteen layers of a special gauze," explained Trumbull, "with about forty thousand watts of backlight- something like four big arc lights to rim-light it. And he got this tremendous, overexposed glow effect. This particular gauze - actually very rare women's stockings from pre-World War II Europe- created a beautiful softening of the light without making it unsharp. If you use a fog filter, or something like it, it makes the image unsharp because it's actually a piece of glass with diffusion on it. But with gauze, part of the camera lens is seeing right through it, without interruption, so it tends to scatter the light without really stopping it from being sharp. Stanley filmed a number of different moves on the Starchild- shots of it entering frame and sliding through frame and so on. Then I airbrushed the envelope that surrounded it onto a piece of glossy black paper, which was photographed on the animation stand and matched in movement to the model, also with a lot of gauze and overexposure."

Kubrick, ever the perfectionist, continued to tinker with his opus even after it had premiered in Washington, New York and Los Angeles, carving a full seventeen minutes out of the original running time. When the film was released in its final form in April 1968, the enigmatic nature of 2001: A Space Odyssey infuriated and delighted, in seemingly equal measure, both audiences and critics- but its confounding ambiguity ultimately proved to be one of its greatest assets and the secret to its enduring appeal. "In the original script," stated Stuart Freeborn, "there was

The Starchild approachable, the aged Bowman is reborn in the Starchild, the next quantum step in human evolution. In the original script, the Starchild was to float in the center of the film, a series of infantile images seen in the photographing space, shot by Liz Moore, rejected the idea of so simply showing the Starchild. Stanley had the idea of surrounding it in a cocoon of light, and in the end decided that all he really wanted was for its eyes to move. The eyes were made of glass, and I built a little mechanism using drives and bearings and some selsyn motors that made them move sideways and slightly up and down."

voice-over narration and the story was very clear. It was a lovely story, very comprehensible. For the longest time, I could not understand what had prompted Stanley to cut out so much of it, dialogue-wise, that it was nearly impossible to figure out what was going on. But as I talked to people over the years, I began to discover that many of them kept going back to the movie because of that very thing. They'd say, 'I've seen it seventeen times- and I still go back and enjoy it, because I invent something in my own mind each time.' Whether or not that was in Stanley's mind, I don't know. It might be he was just scared that if he made it too straightforward somebody would pick holes in it- 'That's ridiculous. That could never have happened because of so-and-so.' I don't know if it was that, or if he really felt it was better to present something far less tangible, just to vaguely suggest things, and let people work out the rest of it for themselves. It certainly happened that way, whether it was his intention or not."

"Everything was 'sort of' supposed to represent something," asserted Doug Trumbull, "but the objective of the picture was to make it so ambiguous that people could interpret it as anything they wanted to. That was Kubrick's main intent, I believe. People like to grab hold of things in a very literal way so they can make sense out of them- but there was none of that with 2001. Kubrick sought not to make sense out of it. It was up to the viewer to interpret it. In that respect, Kubrick succeeded in making a film that is more like a piece of music than a story."

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